First Edition	*January* 1943
Second Edition	*May* 1944
Third Edition	*May* 1947
Fourth Edition	*March* 1952

TEXTBOOK OF SURGICAL TREATMENT
INCLUDING OPERATIVE SURGERY

EDITED BY

C. F. W. ILLINGWORTH

C.B.E., M.D., Ch.M., F.R.C.S.E., F.R.F.P.S. (Glas.)

Regius Professor of Surgery, University of Glasgow

COMPILED BY TWENTY TWO CONTRIBUTORS

Fourth Edition

E. & S. LIVINGSTONE LTD

EDINBURGH & LONDON

1952

PREFACE TO THE FOURTH EDITION

In the three years that have elapsed since the last edition was published there have been many advances in surgical treatment In some fields improvements in technique have brought diseases formerly regarded as incurable within the range of effective therapy in others methods of operation long in use have been perfected or modified or discarded while everywhere increasing attention has been given to pre-operative and post-operative care

In preparing the present edition considerable changes and additions have been made to keep abreast with these developments Every section has been revised many have been greatly amplified and some new chapters have been added.

New contributions have been invited from experts in particular fields of work. Professor Mercer has contributed a chapter on the Surgery of Congenital Heart Disease and Mr W A Mackey a chapter on Arterial Hypertension while Mr A. R Parkes has written a short section on modern methods in the treatment of hand infections

While retaining the general character of the book, we have endeavoured to increase its range of usefulness to Registrars in training and to practising surgeons With this end in view we have paid particular attention to the technical details of operation not only in routine procedures but also in those major operations which come within the scope of the general surgeon.

These changes and the addition of new illustrations to the number of ninety two have inevitably increased the size of the book, but by retaining a factual rather than a discursive approach and by the strict elimination of redundant matter we have been able to keep it comfortably within the limits of a single volume

C F W ILLINGWORTH

SURGERY DEPARTMENT
UNIVERSITY OF GLASGOW
March 1952

EXTRACT FROM PREFACE TO THE FIRST EDITION

SURGICAL treatment implies very much more than the performance of a surgical operation Indeed the actual operation should be regarded as an incident in a course of treatment whose success may depend to a large extent upon ancillary measures of preparation and after-care Manual dexterity and meticulous attention to details of operative technique are indeed the hall marks of surgical craftsmanship, but for students and aspirants to a career in surgery they are less important than a knowledge of surgical treatment in the wider sense In view of these considerations there appeared to be a need for a different approach to the subject than that of a manual of operative surgery Accordingly this Textbook of Surgical Treatment has been designed to cover a wider field and while descriptions of operative technique are included, they have been given their proper place in a scheme which includes all forms of surgical care

The book is intended mainly for senior students and those undergoing training in surgery For this reason particular emphasis has been laid upon the treatment of common diseases and the details of technique of minor and emergency operations whereas major operations and highly specialised procedures have been dealt with in more general terms As far as possible the recommendations have been based on personal experience and where alternative types of treatment are in vogue the writer s preference has been clearly indicated Special attention has been devoted to the choice of methods of treatment to the indications for and against operation, to the selection of the particular type of operation, and to the dangers and complications that may arise while a special chapter is devoted to Radio therapy for which the close co-operation of the surgeon is so necessary

LIST OF CONTRIBUTORS

I AIRD Ch.M., F.R.C.S.
Professor of Surgery University of London Director of Surgical Unit, Post-graduate Medical School of London

W A. D ADAMSON, M.B., Ch.B (Edin.), F.R.C.S (Edin.)
Assistant Surgeon Royal Infirmary Edinburgh.

R. BARNES, B.Sc., M.B., Ch.B (Manch.), F.R.C.S.(Eng.) F.R.F.P.S.(Glas.)
Reader in Orthopædic Surgery University of Glasgow

K. PATERSON BROWN M.B., Ch.B., F.R.C.S.(Edin.).
Surgeon Royal Infirmary Edinburgh

JOHN BRUCE, C.B.E., M.B., Ch.B., F.R.C.S (Edin.).
Surgeon Western General Hospital Edinburgh

A. A. CHARTERIS, M.B., Ch.B., F.R.F.P.S.(Glas.), F.F.R.
Radiotherapist, Western Infirmary Glasgow

B M. DICK, M.B., Ch.B., F.R.C.S.(Edin.), F.R.F.P.S.(Glas.)
Lecturer in Thoracic Surgery University of Glasgow Regional Consultant in Thoracic Surgery (Western Region)

K. FRASER, M.B., Ch.B.(Glas.), F.R.C.S.(Edin.), F.R.F.P.S.(Glas.)
Dispensary Surgeon Western Infirmary Glasgow Assistant Thoracic Surgeon Hairmyres Hospital.

T GIBSON M.B., Ch.B.(Glas.), F.R.C.S.(Edin.)
Consultant Plastic Surgeon Royal Infirmary Glasgow

R. A. JAMIESON M.B., Ch.B., F.R.C.S.(Edin.)
Lecturer in Surgery University of Glasgow

C. F W ILLINGWORTH, C.B.E., M.D., Ch.M., F.R.C.S (Edin.), F.R.F.P.S. (Glas.).
Regius Professor of Surgery University of Glasgow

W A. MACKEY M.B., Ch.B (Glas.), F.R.C.S.(Edin.), F.R.F.P.S.(Glas.)
Assistant to the Regius Professor of Surgery University of Glasgow

T McW MILLAR, M.B., Ch.B., F.R.C.S.(Edin.)
Surgeon Royal Infirmary Edinburgh.

A. MILLER, M.B., Ch.B (Glas.), F.R.C.S.(Edin.) F.R.F.P.S.(Glas.)
Orthopædic Surgeon Victoria Infirmary Glasgow Sectoral Consultant in Orthopædics South West Scotland

W MERCER, M.B., Ch.B., F.R.S (Ed), F.R.C S (Edin)
Surgeon Royal Infirmary Edinburgh

ATHOL PARKES, M.B., Ch.B., F.R.C.S (Edin.)
Assistant Orthopaedic Surgeon Western Infirmary Glasgow

J S M. ROBERTSON B.Sc., M.B., Ch.B (Glas.), F.R.C S.(Eng)
Lecturer in Neuro-Surgery University of Glasgow

I. S. SMILLIE, O.B.E., M.B., Ch.B., Ch.M., F.R.C.S (Edin.), F.R.F.P S (Glas.)
Lecturer in Orthopaedic Surgery University of St Andrews

A. B WALLACE, M.Sc.(McGill) M.B., Ch.B., F.R.C.S (Edin.)
Lecturer in Plastic Surgery, University of Edinburgh

H. WAPSHAW M.B., Ch.B., M.D (Glas.) F.R.C.S (Edin.) F.R.F.P S (Glas.)
Assistant Surgeon Western Infirmary Glasgow

MATTHEW WHITE, M.A., M.B., Ch.B.(Glas.), F.R.C.S.(Edin.), F.R.F.P S. (Glas.).
Visiting Surgeon Royal Hospital for Sick Children Glasgow

W C. WILSON M.B., Ch.B., F.R.C.S (Edin.)
Regius Professor of Surgery University of Aberdeen

CONTENTS

CHAPTER I

PRE-OPERATIVE AND POST-OPERATIVE CARE

SUCCESS in surgery depends not merely upon dexterity in operative technique but on zealous attention to the care of the patient before and after operation Indeed the actual operation is only one incident though admittedly the most important one in a course of treatment designed to restore the patient to health While the value of pre-operative and post-operative care is naturally greatest in "bad risk" cases and in relation to major operative procedures it should not be neglected at any time

PRE-OPERATIVE ASSESSMENT

When operative treatment is contemplated it is necessary to examine the patient with two objectives in mind namely to assess his fitness for the operation and to elicit any special features requiring particular attention before and after operation In other words it is necessary to ask oneself the following questions Is the patient fit to undergo the proposed operation with minimal risk or can he be brought into satisfactory condition by appropriate treatment? If not should the operation be postponed or called off or can its technique be modified to reduce the risk? What particular dangers are to be expected and how best may they be diminished or avoided?

Such an assessment should be attempted in all cases though naturally the decisions reached must be made in the light of such relevant factors as the degree of urgency the character of the operation (whether one of convenience or necessary to preserve life) the skill of the surgeon and his team The clinical history is often of much help in assessing the patient's fitness for operation Particular note is taken of a history of rheumatic fever of symptoms pointing to cardiovascular disease pneumonia tuberculosis and other chronic diseases In addition the interrogation may bring to light features such as a tendency to bleed or an idiosyncrasy to drugs which, if not recognised might lead to mishaps in the post-operative course

The physical examination should be thorough so far as is appropriate to the individual case It would be pretentious and impracticable to demand as exhaustive an examination in the young man awaiting herniotomy as in an elderly person admitted for a major resection but in all cases the surgeon should satisfy himself that no essential step has been missed.

As a routine measure it is important to carry out a full clinical

examination of the lungs heart and blood vessels The blood pressure should always be estimated. The urine is examined for the presence of albumin sugar and acetone

In older patients and in all patients awaiting a major operation the cardiac efficiency should be estimated by an exercise tolerance test Electrocardiography should be performed if there is any indication that the heart is damaged A routine blood examination should be carried out with estimation of hæmoglobin red and white cell count and differential count The blood group should be determined in readiness for blood transfusion A straight X ray of the chest should be taken Other special examinations will suggest themselves in particular circumstances

Lastly in addition to the general assessment of the case attention must be directed towards the site of operation Here the skin must be examined with particular attention to septic lesions A furuncle a patch of intertrigo or other similar lesion which might initiate wound sepsis should be a signal for delaying all but the most urgent operations

Conditions Affecting Operative Risk

While under modern conditions the risk to life of all but the most radical operations has been reduced to very small proportions it is clear that danger can only be avoided if it is recognised in time and appropriate measures taken It is important therefore in assessing each case before operation to bear in mind the various conditions that may affect operative risk

Age—The risks of surgical operation are increased at the extremes of life Infants are prone to infection they become dehydrated easily and they are very liable to ketosis For these reasons at this age period only operations that are urgently necessary should be performed and they should be of as simple a character as possible Procedures of election should be delayed for a year or two or longer if practicable As an example in hare lip and cleft palate the initial operation during the early weeks of life should be limited to simple closure of the lip defect repair of the palate and plastic procedures to improve the appearance of the lip and nose should be delayed to a later stage

Advanced age is not a bar to operation in itself but only in so far as most old people present degenerative changes which add to the immediate risk or predispose to later complications The main dangers are from cardiovascular and respiratory complications such as cerebral thrombosis heart failure hypostatic pneumonia An old man may develop acute retention of urine and succumb to urinary infection with uræmia, while gangrene of the foot may develop as a result of post-operative thrombosis in an arteriosclerotic subject Moreover it must be borne in mind that elderly people are very liable to bed sores and finally that any complication such as mild wound sepsis which would be of minor significance in youth may bring about a fatal issue in old age

It should be recognised that these complications in old age are

usually due only in part to the operation itself but mainly to the immobilisation in bed and the danger of their development can be reduced greatly by early ambulation Indeed it shall be taken as a general rule that in old people every effort must be made to reduce the period of confinement to bed

CARDIOVASCULAR DISEASE

In patients suffering from cardiovascular disease there is a risk not only of acute heart failure during the operation but also of incidental complications such as a cerebral vascular accident during the post operative period

In many cases of severe heart disease the damage is obvious and the main problem facing the surgeon is to assess the danger of operation and weigh it in the balance against the benefit to be expected This is not difficult in cases where operative treatment is a matter of urgency or vital importance One has then to bear in mind on the one hand the risk to life and on the other the long term prospect of better health It will be proper for example to take a considerable risk to relieve a pericardial constriction with the prospect of great improvement in health whereas no such risk would be justified for say a duodenal ulcer

In all cases it is necessary not only to diagnose the nature of the heart disease but also to estimate the cardiac reserve Provided that the reserve is adequate a pronounced valvular defect does not necessarily preclude operation In assessing cardiac efficiency a careful history and thorough physical examination are essential Particular attention should be paid to evidence of cardiac arrhythmias, auricular fibrillation and auricular flutter and heart block are particularly important The blood pressure must of course be estimated and in cases of hypertension a full investigation may be required along the lines indicated on p 502

When the decision to proceed with operation has been made it is necessary on the one hand to do what is possible to improve the state of the heart and on the other to plan the anæsthetic and operation in such a way as to avoid unnecessary strain on the circulation If operation can be delayed a prolonged period of bed rest may be helpful with administration of digitalis or other remedies as indicated

Anæmia.—The assessment of anæmia by simple inspection of the skin and mucous membranes is apt to be misleading and a severe grade of anæmia may be overlooked if reliance is placed on this method. It is a wise plan to estimate the hæmoglobin as a routine at any rate before all major operations In elderly persons the high incidence of pernicious anæmia must be kept in mind

In mild degrees of anæmia it may be sufficient to administer iron for a few weeks prior to operation When the anæmia is more severe transfusion of blood should be carried out It must be remembered that the main danger in anæmia is from myocardial weakness consequent on anoxia and this is not put right at once after transfusion Sufficient time should therefore be allowed between transfusion and operation

to enable the heart muscle to recover its tone *After prolonged anæmia* of severe degree this may involve a delay of several weeks

Obesity—The risk of operation is greater in obese patients for several reasons The obese patient is usually in poor general condition the heart muscle is flabby and overloaded with fat Obesity aggravates the mechanical difficulties of operation particularly in deep intra abdominal dissections and thus adds to the risk of technical errors *Owing to the poor blood supply to the subcutaneous fat wound healing* may be delayed and there is a liability to wound sepsis Finally obese patients are prone to metabolic disturbances such as ketosis and to post-operative pulmonary complications

In emergency operations these dangers must be recognised and minimised by meticulous technique and after-care When there is no urgency a strict reducing diet should be advised and enforced, *operation being postponed until a considerable loss of weight has been* achieved. During the waiting period also the patient should take regular exercise especially walking and should attend the physio therapy department for active exercises under supervision

Diabetes Mellitus.—With modern insulin therapy there is little or no extra risk in diabetes provided steps are taken to prevent ketosis and dehydration If the diabetes is under control all that is necessary *is to maintain the blood sugar at a moderate level and the urine free* from acetone This can be achieved by the administration of carbo-hydrate and insulin in appropriate doses On the morning of the day of operation the usual dose of insulin should be given together with the usual amount of carbohydrate, preferably in the form of sweetened orange juice If oral administration is impracticable owing to vomiting or other cause glucose may be given intravenously

During the operation if it is lengthy an intravenous injection of 10 per cent glucose in physiological saline may be given which serves the double purpose of replenishing the supply of fluid and preventing ketosis

After the operation the urine should be tested for glucose and acetone every three hours and insulin and glucose given as required Routine blood sugar estimations are not necessary if the diabetes has been previously under control For three days after operation the daily carbohydrate intake should be fixed about 80 gm to be given parenterally if necessary The dosage of insulin should be based upon the pre-operative requirement The risk of hypoglycæmia must be borne in mind especially where a septic focus has been eliminated by the operation The nurse in charge should therefore be warned of the possibility of its occurrence and reminded of the early manifestations (hunger abdominal pain, and sweating) and its treatment by the administration of glucose

When the diabetes is not under control it may sometimes be possible to delay operation until control has been gained Often however the defective control is due to the disease such as carbuncle or gangrene for which operation is required. In such a case operation should not be delayed but special care must be taken to prevent ketosis by giving adequate amounts of glucose and insulin

In a patient with coma or with signs of impending coma operation must always be delayed until ketosis has been overcome by intravenous administration of glucose and subcutaneous injections of insulin and vigorous measures must be undertaken to combat acidosis dehydration and peripheral circulatory collapse

Preparation for Operation

Pre-operative preparation is designed to reduce risk, diminish discomfort shorten convalescence and facilitate recovery

1 If the patient is in good general health little preparation is required and indeed in general terms the less preparation the better It is a common experience that convalescence after emergency operations performed without pre-operative treatment is just as smooth as after carefully prepared interval operations the removal of an acute appendix is tolerated as well as the removal of a chronic appendix the closure of a perforated ulcer as well as the excision of a non perforated ulcer

The rigorous starvation and drastic purgation of former days are to be avoided For most operations (excluding those for gastro-intestinal resection and anastomosis) it suffices that on the previous day the diet should be restricted, though with an ample amount of glucose and that all food should be withheld for four hours before operation If the bowels are regular and a good movement is obtained on the day before operation no special measures are necessary Nevertheless as a routine most surgeons advise a laxative followed on the evening before operation by an enema

If time permits the patient should be advised not to smoke for two or three weeks before operation in order to reduce the risk of post-operative chest complications

Skin preparation is carried out one or preferably two days before operation A two-day preparation should be compulsory before operations on the bones or joints If iodine is to be used the patient must be questioned as to susceptibility to irritation or a trial application may be made to the front of the forearm A patch of elastic adhesive may be applied too to give warning of susceptibility to irritation from this source

It is important to ensure a good night's rest before operation and for this purpose a sedative such as sodium barbitone (7½ gr) or pentobarbital sodium (1½ gr) should be prescribed The immediate premedication must be decided in consultation with the anæsthetist As a routine where inhalation anæsthesia is used atropine sulphate ($\frac{1}{100}$ gr) should be injected half an hour earlier to diminish bronchial secretion Morphia (¼ gr) or one of the short-acting barbiturate drugs such as hexobarbitone sodium may also be given

2 If the patient is not in good general health and especially if the operation contemplated is of major character more extensive preparation is required Particular attention must be paid to the hæmoglobin level and the fluid balance It may be necessary to transfuse blood on one or more occasions or to give saline or protein hydrolysate

intravenously Vitamin therapy may be required at this stage while special measures may be demanded according to the nature of the case for example iodine premedication for thyrotoxicosis

Apart from these particular forms of treatment a preliminary period of rest in bed for three or four days is invaluable in many middle-aged patients—though to avoid the risk of thrombosis the confinement to bed should not be complete During this period an ample diet should be given with frequent drinks of glucose in orange juice

If the patient has been accustomed to the use of alcohol it should not be denied Smoking should however be strictly prohibited to diminish the risk of bronchial irritation During this period the opportunity should be taken to find out any idiosyncrasy to diet or drugs Regular movement of the bowels should be ensured by the use of mild aperients

Post-operative Care

Certain routine measures should be adopted after all operations except the most trivial When the patient is returned to bed he should be placed flat with no pillow and with the head turned to one side If shock is present the foot of the bed is raised

Until recovery from anæsthesia free respiration must be ensured by swabbing saliva from the throat and if necessary by holding the jaw forwards A mouth airway may be left *in situ* as an additional precaution

A close watch must be kept on the rate and character of the pulse. The patient must be kept warm by blankets and hot bottles but these measures should not be excessive lest perspiration lead to fluid loss. Fluids should be administered as indicated on p 18

When consciousness is regained if the patient suffers pain or is restless a narcotic such as morphia (¼ gr) or omnopon (⅓ gr) may be given A similar narcotic can usually be given with safety in the evening On subsequent nights opium should be avoided if possible as it increases flatulent distension and if sedation is necessary a barbiturate such as pentobarbital sodium should be administered

Formerly it was the routine practice to prop the patient in the semi-sitting position partly to reduce the risk of chest complications and also after abdominal operations to prevent infection of the sub-diaphragmatic spaces Recently its value in both respects has been questioned

In most cases the best plan is to put the patient in the position of greatest comfort which generally means having the head raised a little on pillows—the position originally recommended by Fowler

Early Ambulation.—A much more important matter is to get the patient moving early Contraction of the leg muscles quickens the return of blood to the heart and increases the cardiac output while it also reduces the risk of thrombosis Body movements moreover increase the general tone and tend to prevent pulmonary collapse The patient should be encouraged to move in bed as soon as he recovers from the anæsthetic After minor operations such as appendicectomy and most operations in the face neck and upper limbs he should be

able to get up the day after operation, while after gastrectomy he should be ready by the fifth day

Enemas and Aperients—The use of enemas and aperients has been rationalised in recent years After most routine procedures all that is necessary is to give a mild aperient such as liquorice or cascara on the second post-operative day followed when necessary, by the patient s customary laxative If gas pains are severe before an action of the bowels has been obtained relief may be obtained by an enema The orthodox flatus enema designed to stimulate contraction of the colon is made up of 1 oz each of a saturated solution of magnesium sulphate glycerin and water to which formerly were sometimes added molasses turpentine and other highly irritant substances Generally a plain soap and water enema is equally effective

Care after Major Operations—Here special measures may be required to control shock to make good any loss of blood to prevent dehydration and maintain the acid base equilibrium With these objectives an intravenous drip is set up during or immediately after operation and administration of saline or glucose solution protein hydrolysate plasma or blood maintained as indicated (see p 18)

Warmth should be applied either by hot bottles or an electrically heated cage If the latter is used care must be taken not to overheat for this will open up the skin circulation and may increase the degree of shock, while sweating naturally adds to the dehydration

POST OPERATIVE COMPLICATIONS

Efficient supervision of the patient before and after the operation undoubtedly reduces the incidence of post-operative complications Nevertheless even with the most careful treatment the road to convalescence and recovery may not be smooth and special care is necessary to ensure the speedy recognition and effective treatment of any complication that develops

In the immediate post-operative phase apart from reactionary hæmorrhage—which at the hands of a skilled surgeon should be very rare—the special dangers are from dehydration acidosis and alkalosis At this stage also a troublesome though less dangerous complication is retention of urine Next come the common chest complications bronchitis broncho pneumonia and pulmonary collapse Venous thrombosis or thrombophlebitis may occur early or late and may prove fatal by causing pulmonary embolism Excessive vomiting and hiccup are rare but distressing features Bed sores add to the discomforts and dangers especially in elderly patients Other complications the treatment of which is described elsewhere include parotitis various intra-abdominal infections wound sepsis and incisional hernia

DISTURBANCE OF ACID BASE EQUILIBRIUM
ACIDOSIS AND ALKALOSIS

Acidosis may arise from several causes such as diabetes mellitus chronic nephritis or the effects of drugs but the most important

causes in the post-operative period are dehydration and liver damage

The manifestations of acidosis are those of dehydration with 'air hunger (increased depth of breathing) Acetonuria may or may not be present depending on the cause of the acidosis The treatment is simple consisting in the intravenous administration of 0 9 per cent saline with 10 per cent glucose If the patient has chronic nephritis alkali should be given in addition either orally as sodium bicarbonate or intravenously as Hartmann's solution

It should be remembered that acidosis is particularly liable to occur in infants and children especially in the presence of infection. Frequently the symptoms and signs of acidosis (particularly cyclical vomiting in children and diabetic coma) closely resemble those of an acute abdominal emergency The presence of abundant acetone in the urine the smell of acetone in the breath and air hunger are characteristic of the *acidosis of cyclical vomiting or of diabetic coma* Laboratory investigations reveal a lowering of the blood CO_2 content (alkaline reserve) These are not found with appendicitis or similar abdominal condition unless there is some associated acidotic condition

Alkalosis results from a relative excess of basic or alkaline substances It is generally due to one of two causes (1) excessive vomiting *leading to a great loss of chloride and (2) prolonged or excessive* administration of alkali for example in the treatment of dyspepsia or of infection of the urinary tract The symptoms are those of dehydration associated with slow shallow breathing and occasionally with tetany The treatment here consists in the intravenous administration of normal saline Potassium is sometimes advisable but must be given with care to avoid sudden cardiac arrest Care must be taken not to give alkali or any alkali producing substance such as Hartmann's solution. There is never any need in post-operative alkalosis to give any acid *producing drug such as ammonium or calcium chloride* Generally the manifestations of tetany disappear after the administration of saline, but if they still persist the intravenous injection of 10 or 20 c c of 10 per cent calcium gluconate is sufficient to bring relief

THROMBOPHLEBITIS

Post-operative thrombophlebitis occurs most commonly in stout elderly people after operations on the abdomen or pelvis While increased coagulability of the blood and the presence of a mild infection may be contributing influences the main factor in its production is venous stasis. For this reason thrombophlebitis is especially apt to occur in the veins of the pelvis and lower limbs The venous stasis may be due to abdominal distension or to pressure on the popliteal vessels by a bolster According to some surgeons a constrained position on the operation table is responsible or the direct pressure of the calf muscles as they lie flaccid during anæsthesia

Two types of venous clotting are recognised (1) Phlebothrombosis in which clotting occurs within normal veins The symptoms and signs are minimal. Since the clot is loosely attached the risk of

embolism is considerable (2) Thrombophlebitis in which clotting occurs secondary to inflammation of the veins Local pain and tenderness are felt and there may be considerable œdema The risk of embolism is not great

To prevent the onset of thrombophlebitis, every effort must be made to guard against venous stasis Before operation the patient must not be confined to bed unless his condition makes this unavoidable During operation the heels may be raised on a pillow to prevent pressure on the calves After operation he must be encouraged to move freely and especially to exercise his lower limbs to promote the flow of blood from the periphery The bed clothes must be left loose or draped over a cage to allow this to be done Dehydration must be overcome and measures taken as required to maintain the circulation If it is necessary to prop the patient up this must be done without recourse to a bolster behind the knee which might occlude the popliteal veins

The treatment of thrombophlebitis has been changed radically following the introduction of anti-coagulant substances It is no longer necessary to immobilise the limb for long periods nor are the smelly and unsightly applications of former days such as ichthyol ointment regarded as essential Of the anti-coagulants heparin should be used if available for Dicoumarol is slow in action must be controlled by repeated estimations of the prothrombin time and even then may lead to uncontrollable hæmorrhage Full details of the treatment of thrombophlebitis are given on p 83

Post-operative Respiratory Complications

These complications are rare after operations on the head neck and limbs but common after abdominal operations They occur with greatest frequency after operations on the upper abdomen presumably owing to the interference with diaphragmatic movements which is apt to result

Chest complications occur most commonly in the winter months presumably owing to the frequency of epidemic coryza sinus infections tracheobronchitis etc They occur with greater frequency in smokers than non-smokers

Formerly these complications were attributed to the anæsthetic particularly to the irritant effects of ether It is now recognised however that they occur with equal frequency after other types of inhalation such as cyclopropane or even after spinal anæsthesia

Consideration of these ætiological factors suggests certain general measures of prophylaxis Abdominal operations of election should not be performed while the patient is in the acute stages of coryza or other respiratory infection If he is subject to such infections or asthma or any form of pulmonary disease if possible the operation should be postponed until the summer months In all cases the patient should be urged to abstain from smoking for three or four weeks prior to operation

In the post-operative phase every effort must be made to ensure

full respiratory movements The patient should be propped up to allow a free range of diaphragmatic excursion and if an abdominal binder is used it must be loose enough to avoid constricting the lower ribs.

As soon as the patient has recovered from the anæsthetic he must be urged to breathe deeply and to expel all mucus from the trachea and bronchi To assist him by preventing pain at the wound the surgeon should compress the upper abdomen firmly while the effort to cough is made This process should be repeated at frequent intervals In addition regular breathing exercises may be carried out under the supervision of a physiotherapist

Bronchitis and Bronchopneumonia.—Under this heading come all grades of respiratory infection from mild tracheo bronchitis to severe bronchopneumonia In the milder cases it suffices to prop the patient up and to apply heat in the form of a poultice or kaolin pack In the dry type of bronchitis inhalations of menthol sometimes give relief In the more severe cases penicillin should be given in full doses and also sulphonamides Oxygen should be administered if cyanosis is present

Pulmonary Collapse (Atelectasis) —This common complication may be patchy or lobular or affect an entire lobe It is generally believed to result from blockage of a bronchus by adherent mucus with absorption of air from the affected lobe It is characterised by a sudden onset generally within forty-eight hours of operation In the more severe types at the onset there is much respiratory embarrassment and cyanosis may be noted Within a few hours the temperature rises and the clinical signs of consolidation develop Fortunately pulmonary collapse is rarely dangerous and in the great majority of cases the condition clears up completely in a few days

The patient should be propped up in bed If cyanosis develops oxygen is administered After the acute phase of respiratory embarrassment has passed every effort must be made to open up the collapsed tubules To this end the patient must be urged to breathe deeply and Carbogen (5 per cent carbon dioxide with oxygen) may be given Sometimes heavy percussion of the chest appears to be of benefit while vigorous movement of the patient from side to side in bed has sometimes appeared to free the mucous plug If these methods fail the plug may be sucked out by means of a tube introduced under direct vision through a bronchoscope

Pulmonary Embolism.—The treatment of pulmonary embolism has been revolutionised as a result of the introduction of anti-coagulant drugs While nothing can be done of course for a large embolus which is almost instantaneously fatal in all other cases if anti-coagulant therapy can be given in time an effective cure may be achieved In brief therefore the treatment is to give heparin to give it in large doses (20 000 units) and to give it immediately (see also p 83)

Hiccup

The cause of this troublesome and even dangerous complication is not fully understood In its severer forms it is seen most often after abdominal operations particularly in association with peritonitis or

paralytic ileus It occurs also in severe retention of urine or in uræmia of any type Occasionally no cause for the hiccup can be detected

In considering treatment attention must first be directed to the cause After an abdominal operation gastric distension must be obviated by continuous suction through a stomach tube If there is evidence of peritonitis the appropriate measures must be taken In elderly patients care must be taken that the bladder is properly emptied and if necessary catheterisation should be repeated Distension of the colon may be achieved by soap and water enemas

Apart from such measures relief may sometimes be obtained by simple carminatives such as chloroform water or peppermint Sedatives may be required such as a barbiturate while in persistent cases it may be necessary to give morphin or hyoscin to give rest from the fatiguing spasms

Post-operative Vomiting

Formerly repeated vomiting was regarded as an almost inevitable feature of the twenty four hours after operation Now owing to modern methods of anaesthesia the majority of patients have no post-operative vomiting and in very few is there more than a transitory phase lasting a few hours

Indeed as a general rule repeated vomiting should be regarded as an indication of some untoward complication such as acute dilatation of the stomach paralytic ileus peritonitis or intestinal obstruction

The first essential in treatment is to empty the stomach by means of a tube and often this treatment alone is immediately effective If necessary the lavage may be repeated or better, the tube may be left *in situ* with constant suction for twelve to twenty four hours As a routine it is a good plan also to give fluids (saline and glucose) intravenously and if there is evidence of dehydration the fluid administered should be adequate to correct the loss Other treatment may be required according to the cause of the vomiting

Retention of Urine

Retention of urine is a common complication Some patients especially men of nervous temperament find it difficult to use a urinal in bed in other cases retention is due to spasm of the sphincters especially after operation for such conditions as hæmorrhoids or anal fissure In yet others it is due to organic disease of the urinary tract such as enlargement of the prostate

After a major operation there is a temporary diminution in the output of urine and quite commonly no urine is passed for eighteen to twenty four hours At this stage however if no passage has been obtained further delay should not be allowed It is first necessary to distinguish between retention of urine in the bladder and anuria due to insufficient supply of fluid or to kidney failure The abdomen should therefore be examined for evidence of distension of the bladder

In most cases micturition may be started by applying hot fomentations to the lower abdomen or by giving a small enema If the nature

of the operation permits the patient may be allowed to sit or stand at the bedside or even to visit the lavatory If this is not possible an acetyl choline preparation such as Carbachol should be given in doses of $\frac{1}{240}$ to $\frac{1}{120}$ of a grain intramuscularly It has a marked effect upon the plain muscle of the bladder and generally stimulates micturition within a few minutes If the first injection fails it may be repeated after fifteen minutes and again after thirty minutes

If these measures fail it is necessary to resort to catheterisation This step should not be delayed too long for if the bladder has been allowed to become over-distended the resulting urinary stasis predisposes to infection of the bladder

Attention must be drawn to another type of retention of urine which becomes manifest only at a later stage after operation This complication results from atony of the bladder and occurs mainly in weak elderly women The retention is of gradual onset and since some urine continues to be voided at intervals the condition may escape notice until the enlarged bladder is observed It must be emphasised that in this type of case as in chronic retention due to prostatic disease the first sign may be the frequent passage of small amounts of urine resulting from overflow incontinence In such cases it is generally necessary to catheterise on several occasions until the bladder has resumed its tone

Bed Sores

Bed sores occur at pressure points such as the sacrococcygeal region and heels They are particularly liable to arise in heavy patients who through old age lethargy paralysis or toxæmia lie flaccid and immobile and especially in patients with urinary and/or fæcal incontinence Prevention is of the utmost importance Careful nursing is essential The patient must be encouraged to move about as much as possible or if unable to do so he must be turned from side to side at intervals The skin over the sacrum must be cleansed frequently dried by applying spirit and powdered The draw-sheet must be kept smooth and clean and care taken to avoid trauma to the skin of the back when the patient is propped up If early signs of pressure appear a large square of adhesive felt should be applied to cover the whole sacral region

Once a bed sore has formed it should be treated as an infected wound. At first dry dressings may be used or penicillin sulphonamide ointment and penicillin should be given parenterally When the slough forms Eusol dressings may be used Later when the slough has separated leaving a clean ulcer the raw area may be covered with free split-skin grafts or a plastic repair may be carried out using a flap of skin derived from the buttock.

Post-operative Involvement of the Nervous System

A **Peripheral Nerves.**—Injury to one or more peripheral nerves may occur as a result of pressure when the patient is on the operating table The ulnar and radial nerves may be caught by the edge of the

table An ulnar neuritis may also be produced during convalescence if the patient has to lie for long periods on his back, particularly if much weight has been lost Injury to the brachial plexus may result from traction on the wrists and pressure on shoulder regions when the patient is in the Trendelenburg position Foot drop due to peroneal nerve involvement may result from pressure on the legs in the lithotomy position or during convalescence from hyperextension of the knees caused by a sagging mattress All these complications can and should be prevented by due care in arranging the position of the patient during and after operation

The apparatus shown in Fig 1 obviates the risk of nerve pressure on the arms and also allows free respiratory movement

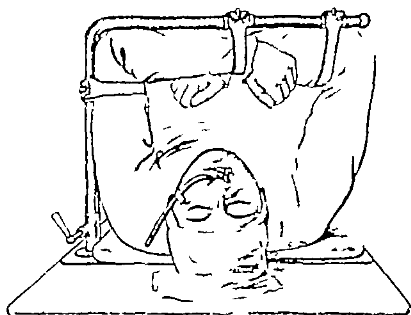


FIG 1

Improved arm support for avoidance of injury to peripheral nerves during operation.

B **Central Nervous System** —In a few cases hemiplegia has been recorded during the first week after operation In some instances this has been due to embolism from various causes or to thrombosis associated with degenerative disease of the cerebral arteries but in others it appears to be the result of post-operative changes in the blood possibly increase in blood platelets Recovery often takes place but there may be a considerable amount of residual paralysis Treatment is expectant

Convulsions sometimes occur during anæsthesia The cause has not been determined but there seems little doubt that a high environ mental temperature and anoxæmia are predisposing factors Con vulsions which occur during the fortnight following operation are generally the result of some cerebro vascular catastrophe Mental disturbances have also been noted in the post-operative period They

are characterised by confusion irritability and hallucinations Generally there is some associated infective or toxæmic process, but excessive administration of sedatives is sometimes the important factor

The Significance of Protein in Surgery

There is little doubt that the nutritional state of a patient profoundly influences the reactions to any surgical procedure Nutrition depends upon an adequate intake of food and its effective absorption and utilisation Defects rarely occur singly and it may be worth repeating the platitude that proximate principles minerals and vitamins are all necessary for optimal metabolism Proteins however form the keystone of the nutritional arch, and if for any reason they are in short supply all the vital processes are impaired

There is considerable evidence to indicate that long standing reduction of the plasma proteins may result in retention of fluid in the tissues altered motility of the gastro intestinal tract increased susceptibility to infections and the development of bed sores and ulcers Hypoproteinæmia is also said to increase any tendency to collapse of the peripheral circulation (shock) after even very slight loss of blood or trauma Some workers hold the view that many of the reactions which follow major surgical procedures particularly in patients with liver disease can be avoided if the serum protein concentration is maintained at a satisfactory level. Following injuries of various types there is an excessive excretion of protein catabolites so that during the recovery phase a considerable amount of extra nitrogen must be retained to make good the loss of tissue protein In addition a considerable amount of protein must be synthesised at the site of healing and for this an abundance of the essential amino acids is necessary

It is practically impossible in ordinary clinical work to obtain a complete picture of the protein economy of any individual patient but much information can be obtained from the previous dietetic and clinical history especially changes in weight The determination of the plasma protein concentration is of value but it should be noted that this may be misleading since dehydration occurring in a patient with protein deficit may lead to an increase in plasma protein to a normal value In interpreting an estimation of plasma proteins it is therefore of importance to take into account this possibility It must also be remembered that plasma protein is a conglomerate of various fractions each of which has a different function it occasionally happens that an increase of one may mask a deficit of another

Serum albumen itself reflects the changes in the protein nutrition of the body as a whole It is of special importance in maintaining the colloid osmotic pressure of the circulating blood and when it becomes greatly reduced fluid may leave the blood vessels and gather in the tissues to produce water logging which in slight cases may not be detected even by very careful clinical examination

Globulin is intimately associated with immunity With the

fractionation of the various globulins in almost pure form the possibility may be visualised of improving the patient's resistance to various types of infection This however is not yet within the realm of the clinician Fibrinogen is an important factor in producing coagulation of the blood A few cases of congenital deficiency of plasma fibrinogen have been described, but generally no lack of this protein need be anticipated unless there is a gross impairment of liver function Another protein fraction, prothrombin concerned in the coagulation of the blood is also reduced in liver disease and particularly in cases of obstructive jaundice where the absence of bile from the intestine prevents the absorption of vitamin K, which is necessary for the synthesis of prothrombin

Deficit of plasma protein may occur very rapidly or may be of slow development Rapid depletion occurs as a result of severe hæmorrhage serious and widespread burning general peritonitis and intestinal obstruction Chronic hypoproteinæmia may be the result of defective food intake liver disease nephritis with gross albuminuria defective absorption such as may occur after short-circuiting operations and in sprue chronic ulcers and sinuses, increased tissue breakdown due to a prolonged infection and after repeated withdrawals of fluid from body cavities It has been reported in severe degrees of hyperthyroidism and is very common in patients with cancer, especially when the gastro intestinal tract is involved

It is obvious that the nutrition of a patient who is to undergo an operation is of supreme importance for his future welfare Whenever possible the oral administration of food is the method of choice for providing the necessary energy, protein and other constituents Sometimes however, the demands for nitrogen are so enormous that it is literally impossible to supply the necessary amounts by the mouth It has to be remembered that a reduction of 1 gramme per cent in the plasma protein concentration indicates a total loss of about 30 grammes in the circulating blood quite apart from the loss sustained by the tissues in general If there is associated anæmia the state of affairs is still more serious, and it has been estimated that some anæmic patients require no less than 200 grammes of protein per day for the synthesis of an adequate amount of hæmoglobin Very few individuals can ingest more than 180 grammes of protein daily without revolting in a week or two If the patient is suffering from lack of appetite and sometimes actual anorexia it is clear that other measures must be adopted Intravenous administration of plasma is of value when the protein loss is acute and of recent origin particularly after hæmorrhage or severe burns When however the inanition is long standing, fantastic amounts of plasma would be required to make good the protein deficit In such conditions casein hydrolysate has been found of value particularly when associated with what one might call forced feeding by gastric intubation In all cases it should be emphasised that treatment must be started as soon as the potentiality of protein deficit arises once clinical signs have appeared successful results are not easily obtained

Diet.—The patient's diet must as far as possible be determined

by his likes and dislikes It should however, contain an ample supply of the energy yielding fats and carbohydrates for without them there is an excessive wastage of protein Vitamins, especially the B complex and C and minerals such as calcium and iron must be in ample supply There is evidence that vitamin C is of importance in the formation of intercellular substance and the B complex for protein synthesis Milk which may be skimmed if there is any intolerance to fat eggs lean meat and soya bean flour are all valuable in building up the tissue proteins When there is any deficiency of proteolytic enzyme such as occurs in pancreatic achylia after some of the short-circuiting operations in coeliac disease and as a result of intestinal rush as in ulcerative colitis hydrolyzed protein which contains a large amount of amino acid in relatively small bulk may be given by the mouth The hydrolysate may also be given by gastric intubation

Nasal stomach tubes of medium calibre are generally used for several hours each day or may be retained for two or three days when they should be removed cleaned and replaced The nutrient mixture may be supplied in separate feeds about 200 c c in bulk or may be given in a drip apparatus By intubation a daily intake of about 150 gm of protein and 2 500 calories should be aimed at in addition to 50 gm or more of protein and 1 500 to 2 000 calories by the mouth If any more is necessary it will generally have to be supplied by intravenous administration It is wise when giving thus high protein and calorie diet to supply an abundance of vitamin Lund and Levenson suggest a daily intake of 1 500 units of vitamin A 1 500 units of vitamin D 250 mg of ascorbic acid 9 mg of vitamin B_1 6 mg of riboflavin and 60 mg of nicotinic acid If intravenous alimentation is found necessary the doses of the B and C vitamins are given parenterally and increased to B_1 20-40 mg riboflavin 20-40 mg nicotinamide 150-300 mg and ascorbic acid 500-1 000 mg

Intravenous Therapy —If there is an urgent demand for protein it is best given as whole plasma or if available plasma albumen When the need is not so pressing some form of casein hydrolysate may be used up to 225 gm of protein equivalent have been given in this form in twenty four hours The addition of glucose has been *recommended by Butler and Talbot* 300 c c of 50 per cent glucose is added to 1 litre of 5 per cent casein hydrolysate giving a mixture of about 12 per cent glucose and about 4 per cent hydrolysate This is given intravenously over a period of about four hours if given too rapidly nausea is apt to occur Enzyme prepared hydrolysate is to be preferred since the acid hydrolysate tends to produce venous thrombosis Occasionally there may be febrile reactions but these are usually not serious If prolonged intravascular administration is necessary and the veins are sclerosed the hydrolysate can be given intrasternally at the rate of 300 c c per hour For infants Hartmann prefers the subcutaneous route but glucose should not be added to the infusion if the plasma protein is very low or the peripheral circulation is poor since any crystalloid tends to withdraw water from the blood and tissues C F W I

MAINTENANCE OF THE FLUID BALANCE

The importance of maintaining the fluid balance in surgical patients is well known. Indeed, the benefit to be obtained by saline infusions in severe dehydration is so striking, and the technique of administration is now so simple, that there is a risk that this method of treatment may be advised as a routine in all gravely ill patients, whether dehydration is present or not.

In many conditions, however, notably in traumatic shock, hæmorrhage and burns, it is now known that saline infusions have rarely more than a transient value and may even be harmful, while their administration in the absence of dehydration may invite disaster from saline overdosage and waterlogging of the lungs.

It is clear, therefore, that success in treatment demands a knowledge of the physiological factors concerned in the maintenance of the fluid balance.

DEHYDRATION

The cause of dehydration is usually a combination of diminished fluid intake with increased loss from vomiting, diarrhœa, sweating or a fistulous discharge. A familiar example is the dehydration which results from the vomiting of high intestinal obstruction. It should be noted, however, that diminished intake may alone be responsible. Thus dehydration is common in patients who suffer from prolonged nausea, who are too weak to respond to the stimulus of thirst, or from whom drink is deliberately withheld following operations on the stomach.

The effect of dehydration is interference with tissue metabolism, and the disorder is aggravated by the onset of acidosis :—

Interference with tissue metabolism is mainly due to depletion of extracellular tissue fluid which is essential for the transfer of metabolites between the blood and the body cells. In dehydration, tissue fluid is rapidly drawn into the blood to compensate for loss of water and electrolytes, for the plasma proteins tend to become concentrated and their osmotic attraction increases. The tissue fluid, thus drawn upon by the blood stream, is itself unable to draw upon intracellular fluid which is an integral component of protoplasm. Intracellular fluid is not abstracted till dehydration is so severe that recovery is improbable.

Acidosis is initiated by the retention of the non-volatile acid products of katabolism. These are excreted only by the kidney, and when the output of urine is reduced they tend to accumulate in the blood. Later, further quantities of acid are produced by the incomplete oxidation of fats during the starvation which accompanies nausea and vomiting. Fatty acids are not oxidised beyond the stage of hydroxybutyric and aceto-acetic acid when the metabolism of carbohydrate becomes deficient on exhaustion of the glycogen reserve. The reserve in adults is sufficient to last for thirty-six to forty-eight hours. In children the reserve is small, while in diabetics it is not only small but incompletely utilised, and the onset of ketosis is correspondingly rapid.

The diagnosis of severe dehydration is based on simple bedside observation Thirst and oliguria are the leading features and occur early Later the eyes are sunken and lustreless the features pinched and drawn and the skin dry and inelastic In infants the fontanelle is depressed When ketosis is present acetone may be smelt in the breath

Laboratory tests confirm the clinical diagnosis but add little helpful information The small quantity of urine secreted is highly concentrated chlorides are diminished or absent and ketone bodies may be present There may be many alterations in the composition of the blood Of these reduction of the alkali reserve is one of the most constant and diminution of the blood chlorides is common

Treatment of Dehydration—The aim of treatment is to replace the lost fluid and thereafter to maintain a normal fluid balance It is of fundamental importance to appreciate that water cannot be retained in the body except as a solution rendered isotonic by its content of crystalloids or of protein Simple dehydration (uncomplicated by protein loss) implies a deficiency not only of water but of crystalloids and requires the administration of isotonic crystalloid solution for its treatment The solutions in common use are —

Physiological Saline—The efficacy of saline depends on the fact that sodium chloride retained in the body binds sufficient water to maintain itself in isotonic solution Further the renal output of sodium chloride does not finally balance alterations of intake until after the lapse of two to three days Consequently when saline is administered the greater part is retained in the body for many hours

Hartmann s Solution—This contains in physiological concentration most of the mineral salts found in blood serum In theory its use is more correct than the use of simple saline solution but in practice it has no obvious advantage

Isotonic Glucose Solution—This is retained only for a short time Soon the glucose is oxidised and the water in which it was dissolved being no longer isotonic is excreted Glucose solution therefore is of limited value in correcting dehydration but it is invaluable in the treatment of ketosis The combustion of the glucose allows normal fat metabolism to be resumed while excretion of the surplus water assists in the removal of acids in the urine Glucose solution should not be administered rapidly for if the blood-sugar level is forced above the renal threshold some of the glucose is excreted

Dosage.—It is strongly recommended that dosage be deliberately planned on the basis of (1) initial replacement of the fluid deficit and (2) subsequent maintenance of the fluid balance A plan such as the following avoids the common errors of giving initially too little saline and later too much

In Adults (1) *For Replacement*—The solution of choice is physiological saline because the greater part of this is retained The amount of the fluid deficit cannot be calculated and the dose of saline must therefore be judged empirically It is found that about 2 litres is appropriate if dehydration is moderate and about 4 litres if dehydration is severe There is little danger of overdosage at this stage The saline

is best given intravenously for the sake of speed, and the rate can be about 1 litre in half an hour

(2) *For Maintenance*—The normal intake of sodium chloride is about 10 gm per day, corresponding to 1 litre of saline solution If the patient is febrile and losing salt by sweating, a further litre of saline can safely be given But the total of 2 litres per day should not be exceeded except in special circumstances Thus if there is copious vomiting or copious diarrhœa the volume of fluid lost should be measured and an equal volume of saline added to the basic ration For the majority of patients, however, 2 litres of saline daily is to be regarded as a maximum Clearly it is impossible by giving saline alone to keep within the limits of a safe dose of sodium chloride and yet give an adequate quantity of water This difficulty is met by giving an additional 2 to 3 litres of isotonic glucose solution daily, a small excess of glucose solution is without danger

Finally, the dosage requires to be adjusted in the light of the clinical findings Thus the dose is inadequate if thirst and dryness of the tongue are not relieved or if the daily output of urine falls short of the minimum figure of 30 oz in the adult On the other hand the dosage must at once be reduced on the appearance of the first trace of œdema

In Children—The response to saline is so variable that no useful scheme of dosage can be laid down It is best to make a beginning with a dose of 25 c c of saline per kilo body weight given twice daily and to modify this dosage freely in the light of the clinical findings

Avoidance of Saline Overdosage.—It has already been pointed out that an excess of sodium chloride is not wholly excreted by the kidney for two or three days and that the retained salt "binds sufficient water to maintain itself in isotonic solution Excessive administration of saline must therefore lead to œdema and fatal infection of the œdematous lungs is a common sequel For this reason the dosage of saline requires to be carefully controlled especially after the initial dehydration has been corrected In pneumonia and in some cases of pyloric stenosis there is complete salt retention Here the danger of producing œdema is enhanced and absence of chlorides from the urine is no safeguard against overdosage Again, when the plasma proteins are diminished the osmotic tension of the blood is reduced and fluid tends to accumulate in the tissue spaces The normal range of the plasma proteins is from 7 to 8 5 gm per cent As the value falls from 6 to 5 gm the tendency to frank œdema is increased even with a small excess of salt As the value falls from 5 to 4 gm gross œdema becomes the rule even in the absence of salt excess Care must therefore be taken in treating patients who have suffered from prolonged malnutrition and who then from any cause become acutely dehydrated Lastly extreme care must be taken in giving saline to patients suffering from extensive burns Here the osmotic balance between the blood and the tissue fluid is disturbed by leakage of protein through the abnormally permeable capillaries The spontaneous tendency to acute pulmonary œdema is so readily enhanced that some authorities consider saline to be absolutely contraindicated

Route of Administration —The choice of an appropriate route is made partly on convenience and partly on the speed with which fluid is to be administered

The mouth is the only natural route and when the patient can drink is chosen in preference to all others The natural stimulus of thirst makes for safety in administration for the patient will refuse to drink when dehydration has been corrected Physiological saline is usually accepted with eagerness by dehydrated patients When the briny taste is complained of it can be disguised by adding fruit juice or avoided by diluting the saline to a concentration of 0 6 gm per cent (Saliva contains this concentration of salt) Glucose solution is somewhat nauseating and is best disguised by adding unsweetened lime-juice

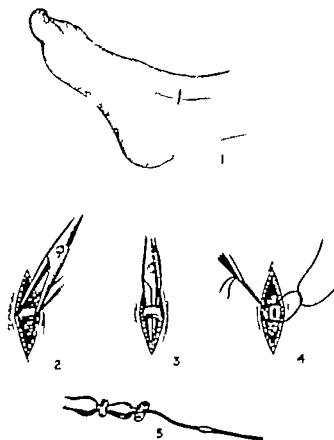


FIG. 9

Intravenous infusion technique of exposing vein at ankle (1) The incision. (2) The vein being cleared by blunt dissection with a hæmostat. (3) The vein dissected free. (4) Ligatures applied and the vein incised. (5) The intravenous cannula.

The rectum can be used for the administration of saline (Isotonic glucose is often given but the practice should be abandoned for there is now ample evidence that glucose given by the rectum is not absorbed) The warmed solution should be run in slowly by funnel and tube every three or four hours in quantities of 8 to 10 oz for adults or 4 to 6 oz for older children Young children are apprehensive and do not co-operate Diarrhœa and inflammatory conditions in the pelvis are contraindications Continuous drip methods of administration have been devised but have not found general favour because they require constant supervision and adjustment

The intravenous route is commonly used in hospitals where the sterility of apparatus and solutions is assured All types of isotonic solution can be given and it is unnecessary to warm them to body temperature Fluid to be delivered rapidly is conveniently introduced through a needle inserted into a vein in the forearm Pro

longed administration is better carried out through a cannula inserted into the great saphenous vein which is constantly to be found at the posterior margin of the tibia a handbreadth above the medial malleolus In infants the veins are small but a determined attempt to use them should be made a soft ureteric catheter serves better than a rigid cannula If no vein can be found the superior longitudinal sinus can readily be entered by passing a fine needle downwards and backwards through the posterior angle of the fontanelle there is some danger of sinus thrombosis especially with the prolonged administration of glucose

If intravenous injection is difficult owing to small calibre of the veins or extensive thrombosis, subcutaneous administration may be used Absorption is greatly hastened by administering hyaluronidase in the fluid

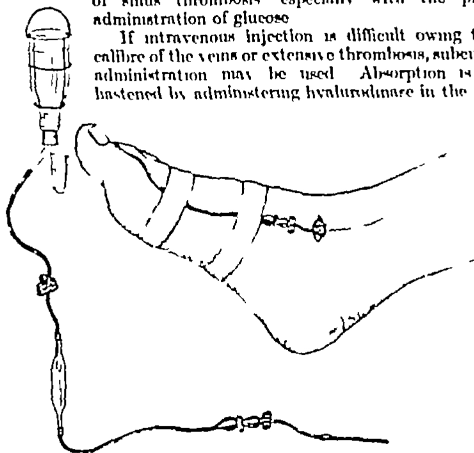


FIG 3

Intravenous infusion. The apparatus consists of a pint bottle with long air-entry tube and short delivery tube leading through rubber tube (controlled by screw clip) to Murphy drip and thence to intravenous cannula. The method of anchoring the tubing by adhesive strapping is shown.

The intraperitoneal route is not used when the intravenous route is practicable but is a valuable alternative in infants There need be no fear of the needle puncturing the bowel for this easily slips aside The route is contraindicated in the presence of intraperitoneal suppuration

The red bone marrow of the sternum immediately below the junction of manubrium and body has recently been used as a route for the administration of plasma or blood in collapsed patients The method is still somewhat experimental

Treatment in Relation to Operation.—After minor operations no special fluid therapy is required for the fluid balance is soon restored

best served by avoiding pre-operative purging and starvation, and by encouraging the patient to drink till within two hours of anaesthesia

After major operations the ability to drink may not rapidly be recovered and moreover there may have been copious sweating if anaesthesia was prolonged It is therefore advisable as a routine to administer saline by the rectum four hourly until the patient is able to take fluid freely by the mouth

After operations *on the stomach starvation and denial of fluid by* the mouth for the first thirty-six to forty eight hours are often ordered in the belief that the empty stomach is quiescent The correctness of such treatment is open to question for it is generally conceded that the empty stomach undergoes powerful peristalsis It appears rational to allow frequent small amounts of saline and to give a modified Sippy diet as soon as the patient evinces a desire for food This view is in harmony with modern teaching on the conservative treatment of hæmatemesis Certainly such treatment is satisfactory in the post operative treatment of duodenal perforation and the misery of dehydration is avoided Supplementary fluid by the rectum should be given Where the orthodox starvation régime is to be carried out it is generally preferable to set up an intravenous drip apparatus and maintain the fluid balance under control

High intestinal obstruction rapidly leads to extreme dehydration It has been estimated that about 9 litres of fluid are secreted daily into the upper part of the alimentary canal as saliva gastric juice bile pancreatic juice and succus entericus Normally nearly all the fluid is reabsorbed from the ileum and proximal colon High intestinal obstruction interrupts the cycle and not only is vomiting profuse but large quantities of idle fluid accumulate in the dilated intestine Intravenous saline should be given generously and when dehydration is already severe operation should be postponed until the fluid has been given Administration should be continued throughout operation into the post-operative period Particular vigilance is required a few hours after operation when circulatory failure is liable to develop Blood pressure estimations should be frequently recorded and if they show deterioration plasma should be given as described below

PLASMA AND BLOOD TRANSFUSION

Plasma transfusion has become a practicable procedure only since the formation of blood banks during the recent war It is of great value in the treatment of shock which follows severe trauma and burns for it provides a rapid method of restoring the blood volume Similarly it is of value after massive hæmorrhage but here whole blood is to be preferred. Plasma has several technical advantages over whole blood. It can be stored for long periods without deterioration is readily transportable and can be given without taking precautions against incompatibility

Blood transfusion is used as an emergency measure after massive hæmorrhage such as may occur in childbirth and may be used as a

routine during operations where the possibility of massive hæmorrhage is foreseen The slow transfusion of large quantities of blood is sometimes useful in hæmatemesis in the bleeding dyscrasias and in severe chronic anæmias

Transfusion in Shock—The circulatory failure in traumatic shock may be regarded as due to disparity between the volume of blood in circulation and the capacity of the vascular bed After severe trauma plasma escapes into the injured tissues as œdema fluid and there is often some external or interstitial hæmorrhage The diminished blood volume is at first compensated by intense vasoconstriction but later if the fluid loss continues or vascular tone is impaired as the result of anoxæmia compensation breaks down and the blood pressure falls

Infusion of crystalline solutions in shock yields only a transitory rise in blood pressure for the fluid quickly escapes through the vessel walls into the tissues Blood plasma on the other hand, has no such disadvantage and is valuable if such simpler measures as rest and the application of heat fail to yield improvement

In deciding the need for plasma transfusion the blood pressure has proved the only reliable guide and blood pressure readings should therefore be taken at quarter-hour intervals and carefully recorded

Plasma should be given if the blood pressure is declining or if it has not risen to the level of 100 mm of mercury after an hour of conservative treatment If the pressure is below 70 mm, plasma should generally be given at once without waiting to see if improvement will take place spontaneously These arbitrary figures should not be interpreted too rigidly and due allowance must be made for elderly patients with sclerosed arteries

When the decision to give plasma is made transfusion should be started immediately At first the administration should be rapid, and at the rate of about 1 pint in twenty minutes Two or 3 pints at this rapid rate may be required to bring the blood pressure up to 100 mm of mercury Even more may be given if the pressure is rising sluggishly but if there is no improvement with the first 3 pints the transfusion should be abandoned for it has repeatedly been found that further quantities are unavailing

When the blood pressure has improved to 100 mm of mercury *the rate of administration should be cut down to the minimum required* to maintain this level Transfusion should now be continued throughout any operative procedure that is required and the surgeon should be as expeditious as careful attention to hæmostasis will allow Blood pressure is estimated frequently for these patients are sensitive even to a small additional blood loss and the rate of transfusion is speeded up if necessary After operation transfusion should be continued at a slow rate for some hours

It will be appreciated that 4 to 6 pints of plasma may be needed for a single patient and if this quantity is to be available plasma must not be given unnecessarily or expended on patients whose injuries are beyond recovery

Shock following burns is treated on similar lines by the generous

use of plasma Saline infusions are not only without value but dangerous (p 41) If the burnt area is at all extensive, the occurrence of severe shock is certain and the infusion of plasma should therefore be started at the earliest possible moment In adjusting the rate of infusion it is helpful to consider not only the blood pressure but the degree of concentration of the red cells and to keep this within normal limits It will be found that plasma is required in large quantities during the first twenty four hours after burning and especially during the early part of this period

Shock following massive hæmorrhage can also be treated with plasma alone but it is preferable to substitute for some of it 2 or 3 pints of whole blood Difficulty in administering blood fast enough can be overcome by attaching a sterilised Higginson s syringe to the air inlet of the reservoir and delivering the blood under pressure The danger of air embolism must be guarded against by making sure that the reservoir is not allowed to become empty

Intra arterial transfusion is a valuable method of giving much blood quickly with the additional advantages of filling the arterial tree and maintaining the coronary circulation without taxing the right side of the heart Using special apparatus the blood is introduced at a pressure exceeding the diastolic pressure through a needle inserted (after exposing the vessel) into the femoral artery

Transfusion in Hæmatemesis—Transfusion is generally given if the blood pressure falls below 70 mm of mercury or if the pulse rate is rising and is over 120 beats per minute Increasing restlessness generally indicates renewed bleeding and is a helpful guide Four or 5 pints of blood are given usually at a slow rate through an intra venous drip apparatus with the object of avoiding any sudden increase of blood pressure which might interfere with clotting at the bleeding point Transfusion is valuable in hæmatemesis to save life during the acute phase of exsanguination and later to shorten convalescence In severe cases its main purpose should be to support life until operation can be performed

Transfusion for Anæmia.—Here the purpose of transfusion is to replace red blood cells There is no circulatory failure and transfusion of blood can thus be given over the course of a few days. The hæmo globin value rises on the average by about 6 per cent per pint of blood given but the rise is far from constant Recently the use of separated red cells suspended in saline has been introduced with the object of avoiding an undesirable increase of the blood volume

Operations in Anæmic Patients—Anæmic patients do not as a rule suffer from systemic disturbances such as undue dyspnœa on exertion until the hæmoglobin value falls below 60 per cent Minor operations can successfully be carried out when the hæmoglobin value is less than this but the margin of safety is small Major operations should generally not be contemplated until the hæmoglobin exceeds 60 per cent When splenectomy is urgently required for thrombocytopenic purpura or for acholuric jaundice continued bleeding may make it impossible to raise the hæmoglobin value to a satisfactory level despite transfusion Here it is necessary to proceed when the maximum improvement has

been secured and transfusion should be continued during and after operation

Major Reactions after Transfusion —Major anaphylactic reactions are rare, and are nearly always due to the administration of incompatible blood Apprehension, dyspnœa flushing or cyanosis pain and syncope occur soon after transfusion is begun The reaction is alarming but seldom immediately fatal The danger period is a few days later when anuria may develop as the result of blockage of the renal tubules by acid hæmatin which is only sparingly soluble Compatibility of blood is best assured by verifying that the recipient and the donor are of the same blood group When this is the case direct typing shows absence of agglutination not only when the recipient's serum is tested against the donor's cells but when the donor's serum is tested against the recipient's cells Blood of the appropriate group may however be unobtainable and it is then necessary to use blood of the universal donor type—Group O Even with this blood anomalous agglutination may occasionally take place and it is therefore undesirable to proceed until direct typing verifies the absence of agglutination when the recipient's serum is tested against the donor's cells When through faulty technique incompatible blood has in fact been given it is advisable for a week to administer sufficient alkali to keep the urine alkaline Alkaline hæmatin is more soluble than acid hæmatin, and the danger of anuria is thus minimised

Reactions due to Rhesus or "Rh" factor —It cannot be too strongly emphasised that major reactions after transfusion are usually the result of giving blood which is incompatible by the ordinary O A B AB grouping Occasionally reactions occur when no incompatibility can be demonstrated by the ordinary tests Some of these anomalous reactions are due to induced sensitivity to the Rh factor

Experimentally rabbits can be sensitised to the red corpuscles of Rhesus monkeys The serum of rabbits so sensitised agglutinates not only the red cells of Rhesus monkeys but also the red cells of some 85 per cent of human beings who are therefore termed Rh positive It is clear that these people are habituated to their own Rh factor and cannot become sensitised to it The remaining 15 per cent of people do not possess Rh factor in their corpuscles and are termed Rh negative It is these Rh negative people who are of importance because in them a state of sensitivity can be induced Induced Rh sensitivity has three clinical applications —

(1) When an Rh negative patient is given over a period of many days a succession of transfusions containing Rh positive corpuscles he may become sensitised and a further transfusion then provokes a reaction This condition is to be suspected when a reaction follows a series of successful transfusions As after other transfusion reactions the urine should be kept alkaline for a week If further transfusions are imperative only Rh negative blood can be used

(2) An Rh negative mother may be sensitised by an Rh positive fœtus and may react even to a first transfusion The condition is to be suspected when there is a reaction to transfusion in a woman who has recently been pregnant If a stock of Rh negative blood is available

it should be used but it is to be remembered that plasma is safe and is almost as effective as whole blood in the emergency treatment of hæmorrhage Again the urine should be rendered alkaline

(3) Finally there are three related conditions which may arise in the Rh positive fœtus of an Rh negative mother these are Hydrops Fœtalis Icterus Gravis Neonatorum and Erythroblastosis Fœtalis Rh sensitivity in the mother usually develops gradually during the first pregnancy and the first born child seldom exhibits any abnormality Subsequent pregnancies exalt the sensitivity of the mother and some of her antibody is carried over into the fœtus and causes blood destruction Hydrops fœtalis cannot be prevented and always leads to still birth A living baby may be delivered suffering from icterus gravis or erythroblastosis and its life may be preserved if Rh negative blood is available for transfusion The probability of one of these conditions arising can be foreseen if earlier pregnancies terminated in the delivery of a macerated fœtus or of babies who died from jaundice or anæmia

It may be useful to point out that at the present time Rh typing is undertaken only at a few laboratories The main applications of Rh sensitivity are found in obstetrical practice and advice on a suspected case is most likely to be obtained at an obstetrical centre where also a stock of Rh negative blood may be available

Minor Reactions after Transfusion.—Minor reactions are common both after plasma and after blood transfusion and are fortunately seldom serious Restlessness and apprehension are generally due to too rapid administration Rigors and pyrexia are generally due to contamination of the transfusion fluid New rubber tubing must be freed by careful washing from the powder with which it is dressed Apparatus which has already been in use must be scrupulously cleaned with soap and water and this in turn must be removed with distilled water before the apparatus is sterilised Sterilisation should be carried out by boiling in sterile distilled water to avoid the presence of dead bacteria Washing soda reacts with rubber and its use by the nursing staff should be expressly forbidden

R A J

REFERENCES

ELMAN R. (1947). "Parenteral Alimentation in Surgery Hoeber New York.
KREMEN A. J (1948) "Parenteral Nitrogen Administration in Surgical Patients. *Surg.*, 23, 0*
MARRIOTT H. L. (1947) Water and Salt Depletion." *Brit med J.*, 1, 245 285, 328.

CHAPTER II

WOUNDS AND WOUND INFECTIONS *

THE medical attendants of a wounded patient are guided by four aims —(1) the avoidance or control of initial shock by early and adequate resuscitation and cessation of hæmorrhage (2) the prevention of infection by appropriate first aid measures early excision of contaminated or devitalised tissue and chemotherapy (3) rest and comfort for the patient and rest for the wounded part by immobilisation and (4) closure of the wound at as early a date as is consistent with safety

The First-aid Treatment.—When the patient is first seen at the site of the accident any arterial hæmorrhage must first be controlled preferably by the application of artery forceps and immediate ligation of the bleeding vessel Only if difficulty of attendant circumstances or surgical access makes ligation impossible should recourse be had to the tourniquet If a tourniquet is used it should be applied over thick padding to avoid crushing of nerves as low as possible above the level of the wound and it should be applied as tightly as possible if a tourniquet is left applied it should be loosened for a few moments at intervals of 15 minutes Venous bleeding can always be controlled by pressure and elevation and never requires a tourniquet

No attempt should be made at this stage to remove foreign bodies or to remove or replace bone fragments The skin around the wound is cleaned gently with weak dettol or some other available antiseptic the wound is dusted with a fine layer of penicillin or sulphanilamide powder and a sterile dressing is applied

As early as possible after wounding protection is afforded against tetanus by the subcutaneous injection of 3 000 units of antitoxin If gross contamination of the wound is suspected and more particularly if muscle is exteriorly damaged 22 500 units of polyvalent gas gangrene antitoxin may be injected intramuscularly in addition

For evacuation to hospital immobilisation of an injured arm should be afforded by a sling for a severely injured lower limb by a Thomas splint If evacuation entails a long journey and the wound is severe sulphonamide may be given by mouth or penicillin administration maintained during the journey while plasma or blood if available may be administered if there is a risk of the supervention of shock.

Reception of Wounded—When the injured person arrives at his immediate destination a surgical centre it must be decided

* Wounds involving special tissues and in special regions are considered in later chapters

whether he is fit for immediate operation or whether further resuscitation is required to prepare him for operation. In civilian circumstances in peace time, operation should be delayed only until resuscitation is adequate When however after civil catastrophe or military operations large numbers of wounded are admitted to a surgical centre some method of sorting (triage) must be adopted by the receiving officer to ensure that each patient is afforded his proper priority It is usual to recognise four distinct categories of wounded arriving at a forward surgical centre with four corresponding degrees of priority for surgical attention (Ogilvie) —

(1) *Those who need operation or resuscitation at the earliest oppor tunity or they will die* —In this group are included abdominal injuries hæmorrhage from large vessels uncontrolled hæmorrhage from small vessels avulsed or mangled limbs chest wounds with dyspnœa face or neck wounds with respiratory obstruction and severe burns

(2) *Those who need operation not urgently but as soon as possible* — Joint wounds compound fractures large flesh wounds retained foreign bodies of large size

(3) *Those who should be despatched to special centres for their primary operation*.—Wounds of head spine and orbit

(4) *Those who can safely wait for operation and if necessary can be evacuated further for operation elsewhere* —Through and through bullet wounds without hæmorrhage smaller flesh wounds simple fractures and minor burns

Investigation before Operation.—A careful history is obtained of the mechanism of wounding of the nature and the direction of the missile in a wound by shell or gun-shot and of the position of the patient at the time of wounding—these often assist location of a retained foreign body Wounded limbs are examined particularly for fracture and for joint injury and the state of the circulation and nerve supply of the extremity is noted and recorded Colour swell ing peripheral pulses sensation and motor power are particularly observed Wounds of head neck chest abdomen and perineum require even more specialised examination for visceral injury X ray examination is desirable in most cases for the detection of fracture and the location of metallic fragments

Definitive Treatment The Operation.—The aim of operation is to remove all foreign matter all contaminated and devitalised tissue and with it those organisms which have been introduced at the time of injury to leave a clean healthy surface for closure immediately (in the case of most civilian wounds) or at a later date (in nearly all wounds sustained in battle) with no residual dead tissue in which contaminat- ing organisms may flourish and whose separation and sloughing must be awaited before healing can begin The operation most generally employed is a *localised excision* or *débridement*

After the patient has been anæsthetised the wounded part is cleaned. A sterile dressing is placed over the wound and the skin surface of the whole extremity is washed with soap and water and scrubbed with a brush The whole limb is shaved the razor being applied in strokes parallel to the wound edges and the blade being

held at an oblique angle to the line of the wound edge, so that the shavings roll away from the wound If cleansing is thorough, no chemical antiseptic need be applied The patient is draped in sterile towels as for any surgical operation

The wound is cleared of blood clot, dirt, and loose fragments of clothing metal or bone by irrigation or by mopping The devitalised or discoloured skin margin is excised with scissors seldom is it necessary to remove a strip more than a few millimetres broad To afford access to its depths however the wound is enlarged by skin incisions carried outwards in the line of its longest diameter until the skin wound is twice as long as the wound is deep The skin edges are retracted discoloured patches of superficial and deep fascia are removed and the wound in the deep fascia is enlarged by incision across the line of its fibres until it is as long as the skin wound The wound track is now followed through muscle and all dirty, pale or blue muscle is excised until the cavity is walled by healthy muscle which contracts and bleeds when cut As muscle is excised bleeding points are secured , diligent hæmostasis, proceeding step by step with excision, substantially reduces post-operative shock When bone is reached if there is a fracture present, loose fragments are ablated firmly attached fragments are left The ends of the main fragments are not excised unless they have been protruded and grossly contaminated Nerves and large vessels, if their continuity is not interrupted, are not included in the excision even if they are contaminated , their surface is trimmed clean however, and washed with saline or flavine The ends of a divided nerve are approximated by a single suture of thread Divided tendons at wrist or ankle may be sutured immediately only in peace time circumstances and only if the skin too is to be immediately closed

The excision proceeds in a penetrating wound until the missile is found in a perforating wound until the exit wound is reached In most penetrating shell wounds it is convenient to excise from each end in turn

A more *limited excision* is required (1) for clean excised wounds more particularly those of the face (2) for wounds penetrating deep and inaccessible structures (3) for long wound tracks bearing a close relation to important vessels nerves or viscera and (4) for perforating gunshot wounds as opposed to shell wounds

In a deep wound of the buttock hip joint and perineum, for example only the outer portion of the wound should be excised, the depths being cleared of foreign matter by lavage the foreign body being sought and removed if possible by blind palpation and the track being enlarged sufficiently to ensure free drainage The same principles apply to long wound tracks through relatively undamaged muscle In perforating bullet wounds it is sufficient to excise the skin and fascial wounds and to flush out the track Relatively clean incised wounds of the face require no excision—there is little muscle here to be damaged and every millimetre of skin will be required for closure

Chemotherapy —Penicillin and the sulphonamides are mainly

bacteriostatic in their action, preventing the multiplication of organisms and it should be remembered that chemotherapy is employed only as an adjuvant to surgery It cannot replace surgery The most efficient chemical preventive of infection in a wound is the general administration of *penicillin* 300 000 units of procaine-penicillin in oil being given *intramuscularly twice daily* *Penicillin powder may also be administered locally* by insufflation to give uniform coloration of the raw surface but the value of local administration is less certain than the value of general administration

Sulphonamide also may be employed locally or by a general route as a prophylactic against infection but it should be remembered that sulphonamide administration is not without danger and should be reserved for the more severely wounded for those in whom the risk of septic infection or gas gangrene is great and for those who cannot be brought early to operation In most cases penicillin should be used *instead or as well* For *general administration* sulphanilamide is best a loading dose of 2 gm can be given with water or alkali and followed after 2 hours by a maintenance dose of 0 5 gm which can be repeated 4 hourly for 4 days For *local administration* sulphanilamide may be used or S P powder (a mixture of 1 part of proflavine and 99 parts of sulphathiazole) or marfanil Proflavine and marfanil are particularly effective against organisms of the gas gangrene group and marfanil has the additional advantage of remaining active in the presence of pus though its efficiency is reduced in the presence of blood In applying sulphonamide locally to a wound the powder should *be sprinkled uniformly and in sufficient amount to produce only a* frosting Too liberally applied it forms an inert cake from 5 to 15 gm is usually enough Care must be taken not to apply sulphonamide powder to nerve tissue—peripheral or central

Closure of the Wound —In civilian circumstances the wounded patient comes to operation early contamination is not usually gross and the patient can be kept under observation indefinitely in the place where operation has been performed *immediate closure* can usually be performed The wound having been excised and left dry by a complete hæmostasis its edges are apposed by unabsorbable sutures *Buried sutures are avoided*

The skin must be brought into apposition without tension If there has been much skin loss relief incisions may be made parallel to the wound and at a distance to either side of it The relief incisions gape leaving open elliptical wounds but as these are only skin deep healing occurs rapidly In some cases V Y relief incisions or various forms of skin flap may be used to cover the wound

When the skin loss has been greater the choice lies between covering the wound with skin grafts and treating it by the open method The use of skin grafts is particularly applicable to extensive superficial wounds in which thorough cleansing has been possible In such cases the immediate application of Thiersch or half thickness grafts greatly expedites healing

In extensive wounds of the forearm and hand for example in the common degloved hand use may be made of a pedicle flap from the

abdominal wall Parallel incisions are made at a convenient level with due regard to the blood supply and the intervening strip of skin is dissected up as a bridge The hand is then inserted deep to the bridge the edges of which are stitched accurately to the margins of the wound

In war surgery it is almost axiomatic that wounds should not be closed immediately after operation Even with the benefits of penicillin administration immediate closure is permissible only if complete surgical excision has proved possible and if the patient can be kept under observation for some days in the place where operation has been performed In the great majority of war wounds the wound is left open after operation so that drainage from it may be adequate at the completion of operation a gauze pack is laid in the wound loosely to make it as flat and open as possible, but not to act as a plug damming back the wound secretion Over this a sterile dressing is applied

In wounds which have been left open after operation particularly that is, in battle wounds closure is effected by *delayed suture* This is performed usually on the fifth day after excision if the wound has remained free from serious infection A wound is fit for delayed suture if there has been no purulent discharge from it, if the surface has remained healthy, if the edges and the surrounding skin have remained free from redness and œdema, if the regional lymphatic glands have remained free from tenderness and if the patient s temperature has settled Delayed suture or the *provision of skin cover,* at this stage does not differ from the primary closure described above

Immobilisation in Wound Treatment.—If a patient must be evacuated as he usually must in war circumstances after the primary excision of his wound complete immobilisation is afforded to the wounded part whether bone is broken or not A wounded arm is for this purpose best immobilised in a *brachio-thoracic plaster* The excised wound having been dressed the upper limb and chest padded a long slab of plaster is applied from the axilla down the inner side of the arm round the flexed elbow up the outer side of the arm, and over the point of the shoulder to the root of the neck A few circular turns of plaster bandage applied round the arm keep this slab in place The whole plastered limb is bound to the chest by encircling turns of plaster bandage and the plaster case is then split along the outer side of the arm

A wounded thigh is best immobilised for evacuation as follows The wound having been excised and dressed extension strapping is applied to the limb and the whole extremity is swathed in wool A Thomas splint is applied and held snugly against the ischial tuberosity Slings of calico or flannel are looped across the splint to support the limb and drawn tight and a firm pad is placed under the knee or the splint is angled 15 at that level to flex the knee slightly The extension tapes are drawn to a tension of about 15 lb and are tied over the end of the splint Firm pads of wool or other material are laid between the knee and the limbs of the splint to prevent lateral movement and a bulky pad is placed between the

limb and the outer side of the ring to draw the inner side of the ring against the ischial tuberosity The whole limb from ankle to groin is then enclosed in plaster by encircling turns of plaster bandage which include the limbs of the splint and the plaster shell is indented between the outer side of the limb and the splint to press the splint outwards and fix still more firmly its ring against the ischial tuberosity

For wounds of leg ankle foot hand and forearm more limited plaster cases may be employed to immobilise only the joint above and the joint below the wound Plaster cases for evacuation should always be padded and split lest œdema develop in transit and tension within the case produce a vascular occlusion

The principle of immobilisation is applicable not only to wounded patients in transit but to all wounded after the operation for excision Even in static circumstances rest should be afforded to injured or inflamed tissues Immobilisation relieves pain protects the wound from trauma and greatly expedites healing It is most satisfactorily afforded by plaster immobilisation which not only protects the healing tissue from injury from the stress of movement and from secondary air-borne infection but by compression prevents œdema and by reducing lymph flow delays toxic absorption and limits the spread of infection After excision of the wound therefore a wounded extremity is encased either in a skin tight or in a padded plaster

The *unpadded or skin-tight plaster* case gives stricter immobil isation more uniform pressure and less tendency to become loose after a few days It does however carry the risk of interfering with *the circulation of the limb and is employed only if the patient can be* kept under strict supervision Even then it is safer to employ a thin layer of padding under the plaster and so to avoid any risk of such complications as ulceration of skin ischæmia of muscle pressure *paralysis of nerve or even gangrene of the limb To avoid the development* of œdema in the encased limb and a dangerous rise of tension within the plaster a limb enclosed in plaster should always be elevated for at least 48 hours

The Treatment of Infected Wounds.—*If infection does become* established in spite of all precautions its cause must be found and treated The infecting organism is identified and its sensitivity to penicillin or other antibiotics is deduced or estimated Foreign bodies which may have been overlooked and, *if there is a fracture* sequestra are sought by X ray and by operation and are removed free dependent drainage is established by enlargement of the wound or by counter incision a close mesh gauze dressing is applied and complete immobilisation is afforded in a *closed plaster* Penicillin administration is established or resumed if the infection is penicillin sensitive and further recourse is had to the sulphonamides It should be remembered however that a course of sulphonamide repeated after *full sulphonamide prophylaxis is not without risk of inhibition of the* granular elements of the bone marrow and the onset of a leucopenia or even of a fatal agranulocytosis if a second course of sulphonamide is given a copious fluid intake must be encouraged a watch must

be kept for signs of sulphonamide sensitivity (rash, fever), and the white count must be frequently recorded

While sepsis continues attention is paid to the patient's *general condition* He suffers as a rule from anæmia and from a negative protein balance which are reflected in a low level of hæmoglobin and of serum protein If these are severe and untreated generalised œdema gastro-enteritis, cachexia and cerebral symptoms may supervene Hæmoglobin is restored by blood transfusion and protein by plasma transfusion, and quite large and repeated transfusions may be required Throughout the course of the infection a high protein diet is maintained with a generous fluid intake and a liberal content of vitamin C and vitamins of the B complex

The closed plaster method for the treatment of patients suffering from infected wounds should not be an excuse for surgical inactivity The aim in treatment is not only to eradicate infection, but to induce healing As soon as the temperature has settled for 4 or 5 days the plaster is removed If discharge is now slight in amount if the wound is covered by healthy granulations if a thin blue iris of regenerating epithelium is beginning to creep in from the periphery and if the surrounding skin is free from œdema and redness, *secondary suture* should be performed At this operation the whole wound may be excised *en masse* with a narrow margin or the skin edges may be merely undermined and apposed over intact granulations If the defect is too great for simple suture plaster methods may be employed just as in delayed or primary closure Seldom now and then only in the case of certain compound fractures is healing permitted to take place by granulation under a closed plaster I A

TETANUS

Active Immunisation.—It is now possible to confer immunity to tetanus by the injection of formolised toxin or toxoid and this is now carried out as a routine in the British Army Two injections are given They can conveniently be combined with the injections of typhoid paratyphoid vaccine The immunity is believed to persist for a long time and may even be permanent Until further experience is gained however and in view of the fact that the degree of immunisation probably varies in different individuals if a patient who has previously received toxoid is wounded it is generally advisable to induce passive immunisation by administering antitoxin

Passive Immunisation.—This should be carried out as a routine in all cases of wounds contaminated by manure road dust or tilled soil and also before manipulating or opening up any old wound that may have been infected with tetanus The usual prophylactic dose is 3 000 international units of antitoxin If given within a short time of the injury this confers almost complete immunity which however lasts only a few weeks

Treatment of Tetanus.—When tetanus has been diagnosed or even suspected, treatment must be given with the utmost urgency The treatment may be described under four headings

1 *Administration of Antitoxin*—It is of the utmost importance to give antitoxin as soon as possible A massive dose should be given —300 000 units if available The antitoxin is best administered intra venously for in this way it reaches and neutralises the toxins most rapidly The method of intrathecal administration formerly in use is now obsolete After intravenous administration the antitoxin remains in the circulation for a long time so it is unnecessary to repeat the injection for several days The usual practice if recovery is not taking place is to give a further 50 000 units after five days and again a week later

If at the time of the first injection sufficient antitoxin is not avail able to give the massive dose recommended above as large a dose as possible should be given at once and the rest as soon as possible after wards When giving the first injection the risk of anaphylaxis must be borne in mind The injection must be made very slowly Adrenalin solution (1 1 000) should be at hand, and if signs of anaphylaxis appear 5 minims should be given subcutaneously at once

2 *Treatment of the Wound*—Since any interference with the wound may lead to a sudden increase in the absorption of toxins the wound treatment should be delayed until at least an hour after a sufficient dose of antitoxin has been injected

A wound infected with tetanus is generally a small penetrating or punctured wound with little inflammatory reaction round it and no widespread suppuration If the wound is in a part with easy surgical access the most certain method of eliminating the source of toxins is to carry out a block excision of all the infected tissues leaving the resulting wound packed widely open This treatment however is not generally practicable and in most cases all that can be done is to render the wound unsuitable for the proliferation of anaerobic organisms For this purpose the wound should be opened widely extending the incision as far as necessary foreign bodies loose tags and portions of necrotic tissue excised free drainage instituted and finally the wound packed lightly with gauze soaked in hydrogen peroxide If the wound is a deep one Carrel tubes may be left *in situ* for intermittent irrigation with hydrogen peroxide Penicillin is given in full doses

3 *Control of Muscle Spasms*—In the early stages the spasms may be controlled by morphia but when the spasms become severe and generalised they can be controlled only by deep narcosis or anæsthesia The most effective drug is avertin which must be given repeatedly as long as the spasms persist—sometimes for as long as a week. The dose from 0·07 to 0 1 c c per kilo body weight must be adjusted by trial to give periods of narcosis lasting four hours with one-hour intervals of consciousness During the conscious interval the severity of the spasms may be mitigated by morphia If avertin is not avail able paraldehyde may be used instead Evipan is useful to control the spasms temporarily but its action is too transient to make it suit able for continuous use If despite these measures violent spasms continue to recur it is necessary to administer gas and oxygen and even chloroform

4 *General Treatment*—The victim of tetanus requires particular

care and the individual attention of special nurses He should be treated in a single room protected from light and noise, and the utmost care must be taken to avoid unnecessary movement or even such attention as adjusting bedclothes which may act as stimuli for further spasms

Fluid must be given in large quantities The tetanus patient is thirsty and will drink copiously unless prevented by trismus During narcosis fluid may be given also by stomach tube Food is necessary also, for the violent muscular exertion of the spasms demands much energy An attempt should be made to give 1 000 calories daily The food must be given in fluid form by the mouth or by stomach tube C F W I

GAS GANGRENE

The risk of gas infection and the severity of its effects depend upon a number of related factors —(1) Direct damage and devitalisation of tissues especially of muscle, at the time of injury, afford a suitable soil for the growth of clostridia (2) Interference with the blood supply of muscle by damage to its vessels of supply, by severance of the main vessels of the injured limb in a separate and more proximal wound by constricting bandages splints plasters tourniquets or tight clothing at a proximal level aggravated by the protracted low blood pressure which may follow hæmorrhage may lead to massive necrosis of muscle which becomes an attractive pabulum to anærobes (3) Contamination of a wound by highly fertilised soil or by the patient's own excreta or by fragments of his soiled clothing may infect the wound heavily with anærobic organisms these are of importance only however if devitalised tissue offers them the opportunity of growth (4) The presence of a foreign body in a wound produces a progressive devitalisation of the tissue in relation to it and serves as a focus from which gas infection may spread

There are two main types of gas infection anærobic cellulitis and anærobic or clostridial myositis (true gas gangrene)

In **anærobic cellulitis** clostridia are present between the fascial or muscular layers of a wound but are not spreading rapidly and progressively at the expense of increasingly devitalised muscle The wound is dirty with an abundant collection of malodorous gas bubbling up in the wound extending between muscle groups and sometimes localising as a gas abscess There is not much gangrene and any there is can be ascribed to the original trauma There is no great systemic disturbance unless hæmolytic streptococci are present or effect an entrance

Clostridial myositis, liable to occur when a muscle or a muscle group or an extremity is not only infected by anærobic organisms but has lost its blood supply in whole or in part is much more serious and is the true form of gas gangrene There is relatively little gas production but an extensive and progressive death of tissue and a profound toxæmia A similar type of infection may follow infection of a wound by the *Streptococcus pyogenes* or more rarely the *Staphylococcus pyogenes*

Prophylaxis of Gas Infection.—This may be ensured by primary

excision of the wound, by the maintenance of an adequate circulation in the wounded part by the administration of antitoxins and by chemotherapy

Complete primary excision of the wound offers the most certain prophylaxis and every effort must be made to ensure that this is carried out especially in wounds involving muscle No form of chemotherapy or of serum administration will affect the incidence of gas gangrene in a wound deprived of the benefit of adequate operation Since gas gangrene may develop within a few hours of the injury the excision must be carried out expeditiously The excision must be thorough and special attention must be paid to muscle all damaged or devitalised portions being excised ruthlessly until vascular contractile fibres are exposed In deeply penetrating gunshot wounds where complete excision cannot be achieved the wound must be laid wide open to avoid setting up the conditions favourable for anaerobic growth Tension must be avoided in all wounds and especially if in favourable circumstances primary suture is performed

At every stage in treatment an adequate circulation is afforded to the wounded extremity In first-aid treatment constricting clothing is removed or cut tight bandages and splints are avoided and tourniquets are employed only as a last resort Arterial injuries are sought and detected early The padding and splitting of plaster cases reduce the incidence of gas infection as also does early and adequate resuscitation from shock

The prophylactic use of antitoxin is advised in wounds with gross involvement of muscle especially if they are situated in the lower limbs or buttocks and if they are contaminated by road dirt manure or tilled soil and in multiple lacerated wounds of the lower extremity when an upper wound may reduce the circulation to the more distal wounded parts Polyvalent antitoxin is employed the dosage now recommended being 9 000 international units *Cl welchii* 4 500 units *Cl septique* and 3 000 units *Cl oedematiens*

Penicillin appears to be the most potent chemical preventive of gas gangrene if given in an adequate dose—15 000 units intramuscularly every three hours after wounding The prophylactic value of the sulphonamides is disputed but some advantage may be derived from their local and general application as described under wound treatment (p 30) In wounds of the buttocks an attempt may be made to reduce the bacterial content of the stool by the oral administration of sulpho-succidine but to prevent contamination of an extensive gluteal or perineal wound it is more certain and more effective to divert the fæces completely by colostomy

Treatment of Anærobic Cellulitis—*Milder forms of anærobic infection* with liberal gas production slight tissue necrosis, and inconsiderable general toxæmia respond well to surgical treatment The wound is thoroughly opened to permit adequate drainage and to relieve all tension Necrotic tissue is removed and an open bleeding surface is left Penicillin administration is of benefit but sulphonamides are not noticeably beneficial in this form of the disease and anti-gas gangrene serum is not required

Treatment of Clostridial Myositis (Gas Gangrene)—In this more severe form of the disease, tissue necrosis is extensive and progressive and the associated toxæmia is severe and frequently fatal sometimes within a few hours so that prompt treatment is required Surgical treatment, the administration of antitoxin, and chemotherapy have a high value in combination when supported by general measures to combat the toxæmia

The polyvalent antitoxin is best given intravenously with sulphathiazole in a slow continuous drip Three times the prophylactic dose of antitoxin is given together with 8 gm of sulphathiazole in the twenty four hours Penicillin also is exhibited in full therapeutic doses—100 000 units daily by intramuscular drip or injection

The scope of the operation performed will depend upon the extent of muscle necrosis The wound is widely opened and enough tissue is removed to ensure that no part of any infected muscle remains Muscle is presumed to be infected actually or potentially, if it is pale or blue or otherwise discoloured if it fails to bleed or if its fibres do not contract when cut A single muscle or a group of muscles alone infected may be excised entire, from origin to insertion through a long skin incision care being taken to avoid injury to adjacent muscles and their vascular bundles of supply ' group gangrene is probably due to injury of the artery of supply to a muscle group at the time of the original wound

In more extensive gangrene involving more than one group of muscles amputation is often required The amputation must be sufficiently high to enable all the infected muscles to be excised though not necessarily above the level to which gas in the subcutaneous tissues has reached In the lower limb amputation is usually required at the level of the knee or mid thigh No attempt is made to carry out a formal amputation and a guillotine method is usually undesirable The open flap amputation is convenient and since skin infection is unimportant sufficient may be left to allow for retraction If when the limb has been removed gas infection is found in one of the muscles of the stump a vertical incision may be made to enable this belly to be excised After amputation the flaps are left widely open kept apart by a loose gauze pack Secondary suture may be performed when all danger has passed and when the infection has entirely subsided

Last but of high importance is maintenance of the patients general condition and control of the pharmacological effects of the toxins and of the responsible clostridia A high fluid intake and a positive protein balance are maintained by plasma transfusion This alone is not enough however One of the most profound effects of clostridial toxæmia is a progressive hæmolysis of the red cells—an acute toxic hæmolytic anæmia—and liberal blood transfusion is demanded for its control. Several pints of blood may be required daily over a period of several days to maintain the hæmoglobin at a level of 70 per cent or more

CHAPTER III

THE TREATMENT OF BURNS

UNTIL the introduction of tannic acid in 1925 the methods of treatment were legion and most of them were bad. Tannic acid, and later other forms of coagulation therapy were therefore welcomed as a considerable advance and soon came into almost universal use Later experience however emphasised their limitations and disadvantages The large number of burns sustained in the 1939 war gave a renewed impetus to research and many different methods in turn were reviewed and discarded Emphasis at this stage became focused on the control of infection and penicillin and sulphonamide applications came into wide use More recently the much older method of free exposure with the object of providing a dry protective crust has been found to be useful in certain types of case

At present there is no general agreement as to which method is most suitable as a routine Burns differ so much in depth and extent that it is almost impossible to find two comparable series large enough to justify statistics on which to try alternative methods Because of this research has been directed chiefly towards the elaboration and defining of the principles on which treatment should be based These principles and their application to local and general therapy will be indicated here

There are three lines of treatment which may have to be undertaken by the practitioner the first aid treatment the treatment of shock if any and the local treatment of the burned area

FIRST AID TREATMENT OF BURNS

The potential danger of all but the most trivial burns cannot be over-emphasised Apart from shock which is a feature of the more extensive burns infection is the complication most to be feared. In this respect burns may be regarded as an extreme form of open wound which will certainly become infected unless measures are taken to prevent it The incidence of severe infection varies directly with the time during which the burn remains untreated

All but trivial burns should therefore be classified as surgical emergencies requiring thorough cleansing as soon as possible after their infliction and any first aid treatment should be applied with this in mind Where possible cleansing of a burn is best carried out under hospital conditions and to facilitate cleansing a first aid dressing should be chosen which can readily be removed. A thick, creamy oil in water emulsion meets this requirement best Many of the first aid methods

at present in vogue are unsuitable because of the difficulty of subsequent removal Oils and greasy substances are the most popular and even after the most thorough cleansing, a thin infected film may still remain on the surface Jellies unless they contain considerable amounts of glycerine, dry and cake and those containing tannic acid form a thin coagulum which is very difficult to remove Watery solutions also dry and cause the dressing to adhere badly to the raw surface

The first aid treatment should control infection For this purpose we have found Cetyl Trimethyl Ammonium Bromide introduced under the trade name Cetavlon to be most useful In 1 to 1 5 per cent solution it is as good a detergent as soap and in addition has a stronger bactericidal action penetrating more deeply into hair follicles and sweat glands

The Technique of First aid Dressing—In well-equipped First aid Centres with properly trained personnel the following first aid method gives excellent results —With as strict aseptic precautions as possible the burn is cleansed for five minutes with a swab soaked in Cetavlon and all dirt and contamination removed With a pair of sterile scissors any blisters are snipped to provide free drainage but no attempt is made to remove all blistered skin The area is then cleansed once more with a fresh swab soaked in Cetavlon and a First aid Cream * applied with a sterile spatula covered with a layer of sterile gauze a layer of wool and a firm bandage

In cases where no proper facilities exist for first aid treatment and where there may be considerable delay before hospital treatment is secured the burn should be dressed with the same cream without cleansing or opening blisters The Cetavlon and sulphanilamide are usually sufficient to prevent excessive multiplication of pathogenic organisms

Where hospital treatment is available quickly the burn may either be dressed with the above cream or may simply be wrapped in a sterile or clean cloth The cloth should be preferably linen and the burns should never be covered directly with cotton wool which adheres very badly

In addition to the above local treatment where the burns are extensive and likely to be followed by shock (see p 41) administer morphine in full doses keep the patient warm and supply him with abundant sweetened fluid.

*		
*	Sulphanilamide	10 per cent
	Cetavlon	1 „
	Castor oil	25 „
	Beeswax	1 8 „
	Wool fat	1·8 „
	Cetyl alcohol	5 „
	Glycerine	10 „
	with Water	

This formula was designed by Professor J P Todd, Pharmacology Dept. Royal Technical College Glasgow The base is an emulsion of castor oil in water the emulsifying agent being the Cetavlon. Beeswax and wool fat are added to stiffen the cream and glycerine to prevent drying occuring Cetavlon is incompatible with soap and also with lanette wax, the latter being a common emulsifying agent for such bases.

It must be stressed that this cream should not be used as the final application, but as a first-aid dressing only Several cases have been recorded of skin rashes following sensitisation to Cetavlon after repeated or long continued use.

TREATMENT OF BURNS SHOCK

Primary Shock.—In all respects primary burns shock is similar to primary traumatic shock and is probably due to the same causes. It is unusual to see it unless in cases admitted very soon after burning. It is transient and may occur with quite minor burns. It is rarely if ever fatal. Treatment is by morphine and warmth.

Secondary Shock.—This differs in many respects from secondary traumatic shock, the chief difference being the large amounts of plasma-like fluid which may be lost locally from the blood stream. This loss occurs both externally and into the tissues (Figs. 4 to 7) and seems to be due to direct thermal injury to the capillary walls which become increasingly permeable.



Fig. 4

3 hours after burning



Fig. 5

8 hours after burning



Fig. 6

15 hours after burning



Fig. 7

24 hours after burning

Figs. 4 to 7.—Changes in facial oedema occurring after superficial burning of the face. Before each photograph the patient was asked to open her eyes fully. The decrease in oedema in Fig. suggests that the capillaries have recovered, that fluid loss has ceased and resorption is occurring. This phenomenon may be delayed in some cases up to thirty hours after burning.

In an extensive burn this fluid loss leads to increasing hæmoconcentration with a falling blood volume. The blood pressure falls and the pulse rate rises. If uncorrected it may lead to tissue anoxia and death.

Assessing the Degree of Shock.—*The majority of severe burns show* little evidence of shock when admitted within one to two hours after injury. This initial phase of well being, along with the normal pulse rate and blood pressure readings often recorded, is apt to lead the inexperienced to believe that shock will not occur. There is no reliable clinical test for assessing whether or not the patient requires anti-shock treatment in the early stages when such treatment may be vital. This is best decided from the extent of the burn.

It may be considered that adults with a burn involving more than 12 to 15 per cent. of the body surface will develop shock. In children it is difficult to dogmatise, but a burn of 7 to 8 per cent. or over in a young child may cause shock. In assessing the area burned the following *figures*, *based on those of Berkow, will serve as a guide*:—

Area of		
head	6	per cent. of body surface
trunk	38	,,
upper arm	3½	,,
forearm	3	,,
hand	2½	,,
thigh	9½	,,
lower leg	7	,,
foot	3	,,

Although fluid loss is more easily seen in extensive blister burns there is no evidence to suggest that it is greater in superficial than in deep burns. In fact, extensive deep burns appear, if anything, to be more serious than superficial burns of the same extent.

Plasma Therapy.—The importance of adequate replacement therapy will therefore be appreciated. Administration of fluids by mouth, while necessary to relieve the intense thirst, is of little value in relieving the hæmoconcentration, as vomiting is a common feature of burns shock. Transfusions of saline and glucose saline are practically useless, for protein is being lost at the same time as fluid and, if not replaced in the fluid transfused, hypoproteinæmia develops and later water-logging of the tissues and œdema of the lungs. True replacement is only possible with plasma or serum transfusions. Such transfusions are the best therapeutic agent which we have for burns shock.

Plasma and serum are now available in two forms: (*a*) liquid and (*b*) dried. Dried plasma or serum is reconstituted by the addition of sterile water and may be made up in various concentrations. There seems to be no reason to use concentrations above normal in burns shock, although it was suggested that they might withdraw fluid from the œdematous area into the blood stream. In actual practice no such action seems to occur, presumably because the capillaries have lost their properties as a semi-permeable membrane.

It must also be remembered that the plasma which is being transfused does not necessarily remain in the circulation. It undoubtedly

leaks through the damaged capillaries in the same way as the patient's own plasma It is therefore necessary to continue the transfusion until the capillaries have recovered *i e* for a period up to twenty four hours or longer in very severe cases

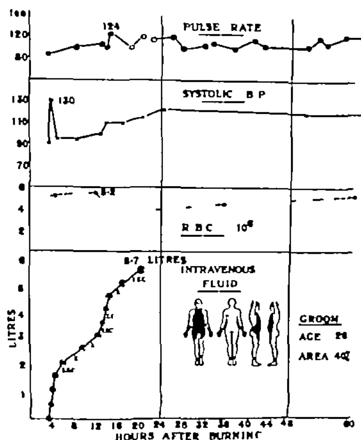


Fig 8

Composite chart of shock period of case shown in Figs. 9 and 10 The large amount of fluid necessary to control hæmoconcentration is shown. Note the fairly constant pulse and blood pressure readings. P=normal citrated plasma E.E.C =ether extracted concentrated serum.

Assessment of Dosage.—The amount to be transfused depends on several factors chiefly the extent of the burn and the age of the patient and perhaps on the depth of the burn and the site Each case must therefore be assessed separately It is futile and dangerous to attempt to calculate the amount required from formulæ based either on the initial hæmoconcentration or on the extent of the burn since we are ignorant of the patient's normal blood picture

The volume of plasma to be transfused is best assessed *while it is being given* and this is done by means of repeated blood counts Venous blood samples should be used but in extensive burns may be difficult to obtain Capillary blood must then be used but the results are not so accurate in the presence of circulatory stasis One attempts to give just sufficient fluid to keep the blood picture at a normal level If hæmoconcentration is increasing the rate of transfusion is increased. Conversely it is slowed if hæmodilution occurs The ideal is to replace the same amount of plasma as the patient is losing at the same rate

as it is being lost Merely to restore to the normal level is insufficient The level must be maintained and in the more severe cases at least transfusion must be continuous until approximately twenty four hours after injury when fluid loss has ceased

Difficulties in Administration—Considerable ingenuity may be required to find a suitable vein in extensive burns The arm veins are by far the best route but when both arms are burned some other site must be sought It is seldom worth while cutting down on a vein through a burn since the œdema which develops may be sufficient to occlude the veins The saphenous veins at the ankle are disappointing Severe spasm of these veins is marked in burns shock and plasma will seldom run in under gravity alone but requires continuous pressure The sternal bone marrow route has been tried but it is difficult to give



FIG 9

Deep burn after three weeks treatment with sulphanilamide cream Dry black slough commencing to separate from the trunk Eusol (1:3) dressings will be applied to hasten the separation of the slough

sufficient fluid quickly enough by this method The external jugular vein is probably the best route in very extensive burns where both arms are involved. The neck often escapes burning and even if it is burned the tissues are so lax that the œdema which develops is unlikely to occlude the vein

Treatment of a Typical Case.—In a young adult with a burn involving about 30 per cent of his body surface who is admitted within two hours of injury the procedure would be as follows —

On admission he is given morphine if he has not already had it and warmth is applied either by means of a heat cage or in a specially heated room Care should be taken that the patient be not overheated. The normal mechanism for heat loss is upset with the loss of the ability to sweat over the burned area The optimum temperature for cage or shock room is probably from 70 to 75 F

No attempt is made to clean up such a burn on admission, but as soon as plasma therapy has begun it is advisable to cover all the burns

with a first aid cream such as given on p 30 Thorough cleansing may then safely be left for twenty four to thirty-six hours when the period of shock is over

A sample of venous blood is removed and without waiting to estimate the hæmoconcentration transfusion of plasma or serum is commenced The first litre should be given rapidly in three-quarters to one hour in order to counteract the hæmoconcentration as rapidly as possible Thereafter the rate is slowed somewhat and adjusted according to the results of repeated blood counts Since fluid loss is very rapid within the first two hours the initial blood count enables us to assess approximately the patient s normal blood level and our aim should be to maintain the blood picture at that level

Transfusion is continued for twenty four hours If the patient is drinking well and has no sickness it may then be stopped completely On the other hand if vomiting be marked glucose saline transfusions should be continued for another twelve to twenty four hours to counteract the dehydration Thereafter it may be given rectally if desired

The Use of Adrenal Cortical Extract.—The use of adrenal extracts and of desoxycorticosterone acetate has been suggested in burns shock since damage to adrenals has been found post mortem in some cases, and also experimental work suggests that it may reduce considerably the period of fluid loss It is said to have had dramatic results in some cases but its usefulness is still *sub judice* When given it should be administered in doses of 2 mg every two hours for the first forty eight hours after burning

Oxygen Therapy—Administration of oxygen has been suggested when circulatory stasis is present There are still however insufficient data available either as to its usefulness or as to the indications for it in burns shock. Adequate replacement therapy will prevent circulatory stasis even in the most extensive burns

THE LOCAL TREATMENT OF BURNS

For practical purposes it is necessary to recognise three types of burns simple blistering in which the only change is the separation of a superficial epithelial layer partial skin loss where in addition to blistering part of the underlying skin has been destroyed although the deep layers of epithelium—the roots of hair follicles and sweat glands—are still viable and lastly whole skin loss where destruction of the skin is complete After removing the blister skin the appearance of a simple blister burn is one of uniform erythema If there is partial skin loss the raw area shows a fine mottling areas of redness alternating with pale areas With whole skin loss blistering is not always present and the appearance is one of dead white pallor or in more extreme cases charring

A simple blister burn will heal completely in seven to ten days with reasonable care Healing is delayed in partial skin loss burns

from two to four weeks depending on the depth of destruction Spontaneous healing does occur however without the need for skin grafting and usually without scarring If the whole thickness of the skin is destroyed there is a gradual separation of the necrotic matter, leaving a raw area which can only heal by scar tissue, or by the use of skin grafts

Most extensive burns are of mixed type Scalds give rise chiefly to simple blistering and partial skin loss Flames or contact with molten metals on the other hand cause mainly whole skin loss the heat being great enough completely to coagulate the skin

While no unanimity of opinion exists as to the best method of local



Fig 10

Deep burn treated again for three weeks with sulphanilamide cream. Observe partial separation of dry black slough from right hand with exposure of tendons The proximal interphalangeal joints were opened with further separation of the slough and necessitated amputation. The left hand was similarly burned. Eusol (1 3) dressings will now be applied to hasten the separation of the sloughs.

therapy the two chief aims are the promotion of healing and the prevention and control of infection Absence of gross infection is a *sine qua non* in the healing of burns and will be discussed more fully

The Prevention and Control of Infection.—Infection particularly with hæmolytic streptococci and to a lesser extent staphylococci is the most serious local complication of burns It leads to delayed healing excessive production of granulation tissue with subsequent scarring and contraction, and may cause septicæmia and death The chief aim of local therapy is therefore the eradication of infection and sepsis and this problem may be tackled in three ways —

Firstly the initial cleansing should be thorough and should be carried out as soon as possible after injury the ideal should be complete sterilisation of the burned area Secondly since it is not always possible completely to sterilise a burned surface and since although cultures

from the surface after cleansing may show no bacterial growth viable organisms may still lurk in the depths of sweat glands and hair follicles the local application should contain some agent to keep down infection. For this purpose drugs of the sulphonamide group are very useful and penicillin and propamidine have been shown to be even more efficient Numerous antiseptics have also been used such as flavine hypochlorites and the dyes

Thirdly *cross infection must be minimised* *The strictest aseptic* routine must be observed at the preliminary cleansing and at all subsequent dressings A no touch technique is by far the best and should be rigidly adhered to Air borne infection is avoided by prohibiting sweeping of the wards for at least one to two hours before



FIG 11
Partial skin loss burn thirteen days after injury Note the prominent skin papillæ visible through a thin film of necrotic dermis.

dressings commence having all windows and doors closed and allowing as little movement of personnel as possible Droplet infection is prevented by *efficient masking of doctors and nurses*

PRELIMINARY CLEANSING

No matter which form of treatment is to be carried out adequate initial cleansing must first be undertaken As a rule general anaesthesia is unnecessary and morphine is adequate in controlling pain All operations should be carried out with great gentleness and only non irritating cleansing agents should be used In young frightened children light gas and oxygen anaesthesia may be advisable but it should not be necessary with older children or adults

Cetavlon is more efficient as the cleansing agent than soap and water With care practically complete sterilisation of the burn may be attained after five to ten minutes cleansing This ideal is only possible however in fresh burns up to about twenty four hours after injury In old infected burns while Cetavlon will readily remove exudate and crusts it is

of little use in reducing the bacterial flora In such cases it is worth while to apply Eusol for twenty four hours because of its lymphagogue and cleansing effect, before going on to the local application proper

Both the burn and the surrounding skin are thoroughly cleansed with swabs soaked in Cetavlon All traces of dirt and first aid dressings are removed and the cleansing should last for at least five minutes Any blisters present are then opened and all loose epithelium clipped away with scissors The raw surface is then given a final cleansing with a fresh swab soaked in Cetavlon and thereafter the local application to be adopted is applied

Spirit or ether should only be used if some first aid dressing has been applied which can only be removed thereby Their routine use may damage further the delicate epithelium

LOCAL APPLICATIONS

Coagulants.—Only a few years ago burns were treated almost universally by one or other of the coagulants—tannic acid silver nitrate triple dye or combinations of these—which coagulate the serum exuding from the burn and form a thin black adherent crust Their main advantage lies in the fact that they seal off the superficial capillaries and prevent further external fluid loss Many of the methods in use however require repeated applications before a dry coagulum results and as most of the fluid loss occurs in the first twelve hours after burning it is doubtful how important this property is In addition fluid loss into the tissues is unchecked

If it is desired to "tan" the burn the coagulant is best applied by means of a brush or swab Various special techniques and various strengths of solution have been described One of the most satisfactory is to apply 5 per cent tannic acid followed one hour later by 10 per cent silver nitrate Occasionally a further application of tannic acid is required to secure an adequate coagulum After each application the skin should be dried by means of a current of hot air from an electric drier

After tanning the part must be kept dry and is left uncovered to permit evaporation A heat cage is used but care must be taken not to overheat which is at least as dangerous as overcooling The skin round the edge of the coagulum should be painted repeatedly with brilliant green to prevent the ingress of infection. If deep suppuration does occur it is necessary to cut away the overlying coagulum and any sloughs present to give drainage

Recently there have been many criticisms of the coagulant methods The main disadvantages seem to be in relation to deep burns The separation of sloughs is delayed and sepsis developing beneath the tan is difficult to control. In superficial burns healing is delayed Their use has been deprecated on the face and especially about the eyelids where the splinting effect may prevent closure of the lids and predispose to corneal ulceration On the hands and fingers they may by their constrictive effect cause stiffness of the fingers or imperil the

blood supply and lead to gangrene Tannic acid itself is a toxic substance and there is now considerable evidence to show that it is the cause of the central necrosis of the liver which has been found post mortem in cases treated by that method

Repeated Saline Baths.—This method is only suitable for well staffed and properly equipped Burns Centres The patient is immersed daily for half an hour to one hour in a bath into which sterile normal saline warmed to 100° F is continuously delivered at a rate of one gallon a minute The burns are thoroughly cleansed at each bath and all necrotic material removed In the intervals the burns are dressed with vaseline mesh—with or without a powdering of sulphanilamide—and covered with saline soaks This method of treatment is most useful in burns about the buttocks thighs and perineum which are almost impossible to keep uninfected

A modification of this method is the use of saline packs The *burned area is covered with vaseline mesh and swabs wrung out in* normal saline are applied These soaks are changed daily although the vaseline mesh may be left undisturbed for a few days and are covered with an impervious layer to prevent drying It is usual to powder the burn with one of the sulphonamides before applying the vaseline mesh

Immediate Excision.—*This method is only suitable for small localised* deep burns on areas such as the thigh trunk or arms The burn is excised down to fascia along with a small margin of apparently healthy skin Hæmostasis is then secured and the raw area covered with large Thiersch grafts By this means the duration of healing is greatly shortened

Innumerable other methods of treatment *have been* described Among those still in use are treatment in closed plaster for burns of the limbs particularly arms and hands irrigation with electrolytic *hypochlorites in waterproofed silk envelopes and the use of thin flexible* membranes containing sulphonamides

Creams and Sulphonamides, etc.—The recent development of various creams in the local treatment of burns has proved a considerable advance and it is this method which the author favours for general use The base is a stiff oil in water emulsion the oil being castor oil or cod liver oil The emulsifying agent is lanette wax SX or similar emulsifier Glycerin is usually added to prevent drying One formula has already been given under First Aid Treatment The following one is simpler and we are indebted to Professor J P Todd of the Royal Technical College Glasgow who designed it —

Sulphanilamide	3 per cent
Sulphathiazole	3
Glycerin	10
Castor oil	25
Lanette wax SX	10
Water	

This cream is smooth bland and easily applied it is miscible with water and thus easily removed and it is an ideal vehicle for the

application of the sulphonamide drugs since it forms a reservoir and thus allows the dressing to remain unchanged for several days It is also ideal for the application of other bacteriostatic agents, such as penicillin and propamidine

A sulphanilamide cream for general use should contain from 3 to 5 per cent of the drug With higher concentrations there is a danger of excessive absorption from very extensive burns The cream is spread on a layer of gauze and stored thus ready for use, or it may be spread over the burned area with a sterile spatula and covered with gauze It is applied immediately after the initial cleansing covered with wool and firmly bandaged

The burn is not re-dressed for at least seven days unless there is an unexplained high temperature Simple blister burns are usually completely healed by this time When it is suspected that the burn is deeper than simple blistering the dressing may remain intact for ten to twelve days After removal a fresh application of cream is made Subsequent dressings are done at four to six-day intervals Sloughs will generally separate in three to four weeks time Eusol dressings soaked three times daily are helpful in removing deep adherent sloughs When all necrotic material has separated and a raw granulating surface results skin grafts are applied

This method of treatment has the merits of simplicity comfort and infrequency of dressings The sulphonamides and penicillin have done much to eliminate infections in burns, but the ideal chemotherapeutic agent has yet to be discovered Some strains of streptococci are completely resistant to the sulphonamides and while these may be eliminated by penicillin there are strains of staphylococci which are resistant to both In addition *Ps pyocyaneus* and *B proteus* are unaffected by either

Propamidine an aromatic diamidine has recently been shown to be almost as lethal to the streptococcus as penicillin and much more powerful than the sulphonamide group of drugs when applied locally It has proved very useful in the treatment of streptococcal infections in burns

OPEN AIR TREATMENT

This old method has recently been modified and brought into use again After a thorough cleansing and removal of blister epithelium the burn is sprayed with penicillin lactose powder and left completely exposed until a dry crust forms which minimises infection and protects the raw surface Whenever possible the burned area should be splinted and should not chafe on the bedclothes It is particularly useful for superficial burns of buttocks thighs and perineum in infants when extension strapping is fixed to both legs and to an overhead beam so that the buttocks are raised from the bed Urine and fæces are voided into a naplin placed under the buttocks and do not contaminate the burn The crusts are not disturbed until they separate leaving a healed surface underneath and, suitably modified the method may be used for almost any superficial burn Deep burns may be treated

thus in the early stages but as soon as the underlying sloughs commence to separate they should be excised surgically and the area prepared for grafting



FIG 1*

Final result of case shown in Fig 0 five months after injury Healing has been obtained in this case chiefly by pinch grafts because of the difficulties of obtaining Thiersch grafts.

ACID DEBRIDEMENT OF SLOUGHS

Recent American work has demonstrated that sloughs can be rapidly separated in deep burns if dressings with a low *p*H are used Pyruvic acid has been most widely used but phosphoric acid seems equally effective The dressing consists of a thick starch paste made with a solution of the acid of *p*H 1 0 This is spread thickly over the burn and covered with an occlusive dressing to prevent drying The dressings are changed at two to three day intervals Sloughs separate within seven to ten days as compared with the usual three to four weeks and thus allow of earlier skin grafting and shorten the period of hospitalisation

SKIN GRAFTING

The importance of early and adequate skin grafting in deep burns after removal of the sloughs cannot be over-stressed By this means the period of healing is shortened scar tissue is minimised and the ugly deforming contractures so often in the past the end result of deep burns completely avoided

Split skin grafts cut either with a razor or with a dermatome are most generally useful Where the raw area is very extensive it may be impossible to obtain sufficient split skin grafts to cover it In such cases pinch or Reverdin grafts are used The aim of skin grafting in burns should be to provide a complete epithelial covering as early

as possible Scarring is thus minimised and later minor cosmetic operations may be performed if necessary In a few cases flap or pedicle grafts may be advisable but as a rule elaborate operations should be avoided in the early stages because of the danger of sepsis

BURNS OF THE HANDS AND FINGERS

Care must be taken when the hands and fingers are burned that maximum functional ability is eventually obtained The arm should be elevated immediately after the first dressing to prevent the occurrence of gross oedema This is best done by applying a splint to the arm and slinging it to an overhead beam It is kept suspended thus for three to four days Thereafter it may be attached for a few days to a counterweight over a small pulley, and the patient encouraged to raise and lower it so that the elbow and shoulder joints are exercised Suspension is discontinued after about a week



FIG 13

Final result five months after injury of case shown in Fig 10 The distal two phalanges of all the fingers and the distal phalanx of the thumb have been amputated because the joints were opened after separation of the slough. The index finger and thumb are covered with thin, delicate epithelium, and there is definite scarring in the webs between the thumb and index finger and the index and middle fingers. Later plastic operations will be necessary in this case

It is controversial whether active movements should be practised from the start or not It is probably advisable however to provide complete rest to the part by splinting the hand in a position of optimum function for a period of one to two weeks Thereafter if the burns have not already healed the hands should be immersed daily in saline baths and active exercises performed

When the burns are deep and involve the dorsum of the hands and fingers joints may be opened when the slough separates In such cases an acute arthritis of the joint develops and depending on the occupation of the patient one must decide whether to amputate the finger or to aim at having a stiff finger in the position of maximum function

BURNS OF THE FACE

Burns of the face heal rapidly as a rule but if deep and if skin grafting be delayed much scarring and disfigurement may result They are difficult to dress and easily infected from mouth and nose The beard area in men becomes crusted and is difficult to cleanse

After cleaning they should be smeared with sulphonamide or penicillin cream and re applications made as often as necessary When crusting has occurred saline packs are useful The beard should be kept clipped as short as possible Masks are very uncomfortable and should not be used unless the burns are deep or flies troublesome

As an alternative if the burns are superficial they may, after cleansing be sprayed with penicillin lactose *powder and allowed to* crust over Spraying is repeated should the crusts crack or separate prematurely because of movement of the facial muscles

If the eye is involved the conjunctival sac should first be thoroughly cleansed by irrigation with saline If the burn has been caused by an acid or an alkali the irrigation must be thorough and prolonged Care must be taken to remove all particles of foreign matter A simple ointment may then be applied or if the cornea is involved an atropine *ointment and the eye protected from light* by a pad Irrigation with saline or boric acid should be repeated thrice daily ointment being applied after each irrigation In the initial treatment a few drops of 3 per cent cocaine hydrochloride may be used for the relief of pain. Later Decicaine or percaine should be substituted for the prolonged use of cocaine damages the corneal epithelium

THE TREATMENT OF MINOR BURNS

Many burns too small to require the hospital treatment detailed above are sustained daily in the home and the factory These burns are superficial causing erythema or simple blistering only It must be emphasised that whenever there is partial or complete destruction of skin the patient should be referred to hospital

The outstanding feature of such burns is the intense pain which lasts for an hour or two after burning Much work has been done to try to find a local application which would relieve this pain using local anaesthetics of various kinds These have proved unsatisfactory The only reliable method is to apply cold If the burn is on the hand or fingers it should be thrust under the cold tap otherwise cold compresses should be used The relief from pain is instantaneous

Later when the pain has lessened the burn should be thoroughly washed with Cetavlon or soap and water Any blister skin should be removed with sterile scissors and forceps and a bacteriostatic dressing applied This may be either one of the creams detailed above or one of the many similar proprietary preparations on the market The dressing should be firmly applied and left in place for one week by which time the burn will have healed

ACCESSORY TREATMENT

A high protein diet is advisable when there has been extensive tissue damage and in view of the importance of the sulphydryl radical in skin healing and the large percentage of sulphur in the skin sulphur rich foods such as eggs should be included

A severe and progressive anaemia is common after extensive burns As a rule there is no iron deficiency and the exact cause is not known Blood counts should be done regularly and small repeated blood transfusions given when necessary

When burns are in the neighbourhood of joints adequate splinting is essential to prevent the formation of contractures In spite of this and early skin grafting there may be considerable stiffness of joints after healing Treatment at a rehabilitation centre with properly supervised active exercises and physiotherapy is very useful in overcoming such disabilities

TREATMENT OF SCARS

Immediately healing has occurred if there is any scar tissue the patient is instructed to massage the area twice daily with lanoline to keep the scar soft and pliable When keloid formation has resulted small doses of deep X rays are useful In cases of extensive scarring with deformity the area is left untouched for two to three months after healing has occurred to minimise the risk of latent sepsis The scar tissue is then completely excised and the raw area skin-grafted the deformity being over-corrected and firmly splinted

T C

CHAPTER IV

AMPUTATIONS

NOWHERE are the changes in surgery during the past century more apparent than in the sphere of amputations A hundred years ago amputations headed the list of major operations now they occupy a humble place overshadowed by many more enterprising achievements within the body cavities In those days amputation was required mainly for compound fractures and foul ulcerating growths now all but the most severe injuries receive conservative treatment and amputation is demanded most often for *the vascular degenerative lesions of the aged In those days—the* days of Liston and Fergusson—amputations demanded masterful dexterity in the use of rapier knives tourniquets and transfixion pins and were accomplished on the conscious patient within the space of minutes now they require no special instruments and are conducted like every other operation with deliberate care

In those days most amputations were of a major character and many different methods were employed Now major amputations are generally limited to a few well-standardised procedures and are comparatively rare whereas owing to the frequency of industrial accidents the so-called minor amputations of the fingers or portions of the hand have assumed a much greater importance

The choice of site for amputation is influenced by the nature of the disease or injury and differs in the upper and the lower limb Thus in immediate amputations for injuries the limb may be divided at any point above the level of the lesion in amputations for malignant growths an adequate margin of healthy tissue must be removed while in amputations for senile gangrene it is often necessary to sacrifice a large part of the limb to ensure an adequate blood supply to the stump

In the upper limb the site for amputation should be chosen to conserve as much of the limb as practicable and to obtain a mobile controllable lever In the lower limb the special need is to obtain a stable painless stump capable of being fitted with a prosthesis and often it is justifiable to sacrifice a considerable *length of viable tissue for* this purpose

INDICATIONS FOR AMPUTATION

Amputation is indicated for severe injuries where the limb is hopelessly mangled or where the circulation is compromised by damage to the main vessels for deformities (especially of the fingers or toes)

causing pain or disablement and not amenable to less radical measures, for severe wound infections including gas gangrene for intractable tuberculosis of bones and joints in adults for primary malignant tumours especially osteogenic sarcoma and for gangrene due to arterial disease The precise indications for amputation in many of these conditions are discussed in the appropriate chapters Special points in connection with emergency amputations and with amputations for gas gangrene and for gangrene due to arterial disease may be considered here

Emergency Amputations.—Amputation as an immediate treatment for injuries of the limbs is indicated (1) where the main blood vessels to the limb are damaged and its vitality thereby prejudiced (2) where the injury is so severe that conservative treatment may be expected to yield a limb less useful than an artificial limb (and this despite recent improvements in artificial limbs implies a considerable disablement)

Formerly immediate amputation was sometimes advised where a deep extensive wound with gross contamination had been untreated for several hours, and where in consequence there was a grave risk of gross sepsis With the introduction of penicillin however the danger in such cases has been greatly reduced and in consequence immediate amputation is rarely indicated

The *technique of amputation* in emergencies must be suited to the individual case Where the operation is performed early before infection is a serious factor a formal amputation should be performed at one of the sites of election In borderline cases a formal amputation may be performed but the wound left open with mattress sutures left loose to be tightened later when the danger of infection is past

Under war conditions it was found wise if the patient was severely shocked to perform a guillotine amputation at the level of the wound formal amputation at a higher level being delayed for two weeks or longer This type of procedure is rarely required in civilian practice though occasionally it may be used in late cases where heavy infection has supervened After guillotine amputation traction should be maintained by adhesive strapping attached to the skin of the stump to prevent undue retraction with the formation of a conical stump with protruding bone The stump may be supported in a shortened Thomas splint with the traction tapes attached to the end of the splint or a 2 lb weight and pulley may be used. The terminal open wound should be treated by the infrequent dressings technique to minimise pain and fluid loss In thigh amputations the femoral artery should be ligated below the inguinal ligament to avert a fatal secondary haemorrhage Later reamputation should be delayed until the granulating wound is clean infection is quiescent and all oedema has subsided

Amputation for Gas Gangrene—Formerly in gas gangrene affecting a limb the only hope of saving life was by means of a high amputation performed as a matter of the gravest urgency With the introduction of chemotherapeutic agents however less radical methods of treatment are often successful

Whenever gas gangrene is suspected, large doses of penicillin are

given (500 000 units) at once and repeated in a few hours time Streptomycin may also be administered

Prompt treatment by these measures may suffice to bring the infection under control though in certain cases with gross damage to the limb or with a particularly violent infection a rapid amputation at a high level may still be required At the other extreme where the disease is limited to the soft tissues it suffices to lay the infected area freely open by wide skin incisions In more advanced cases it will be necessary to incise the limb widely and to excise any obviously diseased muscle bellies Only exceptionally is it necessary to perform immediate amputation

When amputation is required it must be performed at a level sufficiently high to guard against spread of the infection in the muscles of the stump and as an additional safeguard the wound must be left completely open until it is evident that spread has not occurred. To allow for the retraction of the soft tissues which inevitably occurs under such conditions the skin flaps should be made unusually long since gas gangrene spreads almost exclusively in the muscle planes leaving the overlying tissue intact sufficient skin is usually available Subsequently the skin flaps are released and the wound closed by secondary suture If muscle retraction has occurred if the bone protrudes far beyond the soft tissues or if as often happens the end of the bone undergoes necrosis it is preferable to perform a clean amputation at a higher level

Amputation for Gangrene due to Arterial Disease—In *senile gangrene* if the necrosis is of limited extent and free from infection amputation may be avoided or delayed for many months This should be the aim especially in persons enfeebled by old age or widespread arterial disease in fitter subjects on the other hand amputation may be advised early One of the strongest indications for amputation is the occurrence of pain which is often so severe and persistent as to cause great disability and prevent sleep

In choosing the site of amputation the extent of the arterial occlusion must be borne in mind In most cases of senile gangrene the popliteal artery is occluded by thrombus and any amputation below the knee is beset by great risk of necrosis of the skin flap Consequently most surgeons advise either an amputation in the lower third of the thigh in which the blood supply from the profunda femoris artery is utilised or a Gritti-Stokes amputation in which the anterior skin flap is nourished from the patellar anastomosis Occasionally however in gangrene of very limited extent it is justifiable to remove the affected toe the skin flaps being carefully sutured without tension Only rarely in cases which respond well to the various tests of circulatory efficiency is it justifiable to consider an amputation in the mid leg or at the ankle

In *gangrene due to thrombo-angiitis obliterans* the same considerations in general hold good with the exception that since the patient is younger and can be expected to wear an artificial limb it is sometimes justifiable to risk a mid leg amputation in the hope of retaining the use of the knee joint.

In *diabetic gangrene* the principles of treatment have been revolutionised by the introduction of penicillin, and it is now rarely necessary to consider immediate amputation

Penicillin should be administered in full doses and insulin given to control the disturbance of carbohydrate metabolism After using these means the gangrene can be arrested when the subsequent treatment is as for cellulitis

GENERAL PRINCIPLES IN TECHNIQUE OF AMPUTATION

Modern amputations call for no specialised technique or special armamentarium they should be performed like any other operation carefully and deliberately with none of the dash and drama of pre anæsthetic days.

The position of the limb should be such as to facilitate the operation The arm should be held by an assistant abducted at right angles to the body the leg should be held projecting beyond the end of the table its fellow being flexed at the knee and held out of the way

Whenever possible a tourniquet should be applied, except in cases of severe arteriosclerosis in which no excessive bleeding is to be expected and there is a certain risk of damage to the thickened artery by tourniquet pressure In high amputations when it is impossible to apply a tourniquet the main vessels of the limb should be exposed at the start of the operation and ligated

The Incision.—The incision is designed to provide sufficient skin to cover the stump neatly but without tension In the upper limb when a terminal scar is desirable a circular incision or equal flaps are both satisfactory but since a long stump is of prime importance the flaps often must be fashioned so as to utilise whatever skin is available In the lower limb it is so important to obtain tough healthy skin capable of bearing the pressure of a prosthesis that length must often be sacrificed and since the scar should not overlie the bone end it is found satisfactory to use long anterior and short posterior flaps an elliptical incision leaving more skin in front than behind achieves the same purpose Special modifications of these incisions are used for amputations of fingers and toes and are described in the appropriate place

One general rule proves useful in designing the incision the combined length of the flaps should equal one and a half times the diameter of the limb at the level of bone section.

Division of Muscles.—Formerly it was thought necessary in all amputations above the wrist or ankle to retain sufficient muscle to cover the bone end in order to form a weight bearing pad In modern prostheses however the pressure is taken on the sides of the stump and no end bearing is necessary or desirable For modern prostheses moreover a bulky rounded stump is a disadvantage for it entails the fitting of a leather lace-up gaiter in place of the customary metal socket Consequently a slightly conical stump is desirable and to obtain this the muscles should not be sutured over the bone except perhaps in thigh amputations

Division of the Bone.—The site of bone section having been chosen the periosteum is incised and the bone sawn across Whilst this is being done the soft tissues must be protected from the saw and from bone dust

The treatment of the periosteum varies at the hands of different surgeons—some denude the distal inch of the stump others leave a cuff of periosteum to clothe round the sawn end but the end results seem to show no difference

When the bone has been sawn across all rough portions should be removed by rasps or rongeurs or a projecting edge may be eliminated by an oblique saw cut The bone marrow should be left untouched

Treatment of Nerves—The most frequent cause of a painful stump is a sensitive neuroma incorporated in the scar To guard against this all sensory nerves should be isolated and divided cleanly Some surgeons advise that the nerves be crushed with a hæmostat and ligated prior to division while others also advise the injection of 95 per cent alcohol into the nerve above the point of section. Equally good or better results are obtained if the nerves are divided cleanly a short distance above the level of bone section without crushing ligation or injection.

Treatment of Blood Vessels.—As in every type of operation careful attention to hæmostasis is of first importance When the limb has been removed the main vessels are dissected clear and ligated separately with chromic catgut Some surgeons advise double or triple ligation of such large vessels as the femoral artery The tourniquet should then be removed and all smaller bleeding points secured and ligated with plain catgut Since even the greatest care will not guard completely against the possibility of a hæmatoma in major amputations it is wise to drain the end of the stump by a strip of rubber dam for forty-eight hours

POST-OPERATIVE TREATMENT

After amputation special measures must be taken to ensure that the stump will be capable of standing the strains imposed by an artificial limb and active exercises and training must be instituted to enable the patient to make full use of the artificial limb at the earliest possible time

At the conclusion of the operation a firm bandage should be applied over an adequate dressing to maintain uniform gentle pressure and thus diminish oozing into the dead space under the skin flap To immobilise the stump diminish jerking movements and prevent flexion contracture it is often advisable to apply a splint or in the case of thigh amputations to fix the limb between sandbags

When the skin wound is left open to overcome sepsis or in cases where the flaps are sutured under tension the tendency to retraction of the flaps may be overcome by fitting a shortened Thomas splint to the limb and exerting traction through adhesive strips applied to the sides of the stump

When the wound is healed treatment must be instituted to prepare the stump for an artificial limb To prevent œdema and to produce a

stump tapering at the extremity a firm bandage should be worn A crêpe bandage is best It should be applied from below upwards with the greatest tension at the extremity of the stump, and in the case of a thigh amputation it should be carried up to the groin as high as possible The bandage should be reapplied daily

The skin should be toughened by daily applications of spirit followed by powder To prevent atrophy of the muscles and to develop them for use with the artificial limb frequent exercises should be carried out The best method is to fit a canvas sock to the stump and attach it by a cord to a weight and pulley or to a light spring so that the various groups of muscles, and particularly the abductors, may be exercised against resistance It is necessary to emphasise the importance of these measures in training the patient to enable him to make full use of the artificial limb The exercises should be performed regularly under expert supervision

Tender Stumps.—An amputation stump should be smoothly rounded not bulbous painless on pressure free from œdema or circulatory impairment and covered with healthy mobile skin Any shortcoming in these respects—usually the result of infection—will prevent the proper use of an artificial limb

One of the commonest causes of pain is a "stump neuroma" a spindle shaped swelling of regenerated fibrils arising in a sensory nerve implicated in the scar The neuroma is extremely sensitive to pressure causing intense shooting pains referred to the phantom limb and thus renders the stump entirely unable to bear the pressure of a prosthesis The diagnosis of stump neuroma is made by the presence of marked hyperæsthesia at a point in the scar corresponding to a sensory nerve The treatment is to dissect the neuroma out of the scar tissue and excise it

Apart from a neuroma the scar may be tender as a result of adhesion to the bone or from pressure by the prosthesis In some cases an inflamed bursa between the scar and the bone end is responsible A thickened, inflamed or puckered scar is especially apt to be painful In all such cases the treatment is to excise the scar and to cover the bone end with healthy pliable skin To achieve this it may be necessary to remove an inch or so from the end of the bone

Persistent or recurring ulceration in the scar results from low grade infection in an area of impaired circulation The scar is often found to be a terminal one adherent to the bone and the surrounding skin is thin blue and puckered The bone may also be infected and there may be a sequestrum The treatment in such cases is difficult If sufficient of the limb is available the most satisfactory procedure is to reamputate at a considerably higher level. If this is not practicable the terminal inch of the bone may be resected through a short lateral incision Subsequently skin traction should be applied to relieve tension on the ulcerated area and elastic bandages should be used to diminish œdema Furunculosis is a common trouble especially at the sites of pressure by the prosthesis It is partly attributable to sweating within the socket of the prosthesis and may be prevented to some extent by spirit applications and by changing the sock daily

The Artificial Limb—After amputation the stump slowly shrinks as every constituent tissue undergoes atrophy and the final fitting of the limb must be delayed until this process is completed Normally it occupies five or six months but *this period may be shortened by* bandaging and regular exercises described on p 50 Moreover it is often possible to fit a limb with a temporary socket which can be replaced by a permanent one when the shrinkage is complete It is important to get the patient accustomed to an artificial limb as soon as possible and for this reason the limb maker should be consulted as soon as the wound is thoroughly healed

The fitting of the artificial limb should be entrusted to a skilled limb maker The method adopted is to take a plaster of Paris cast of the stump upon which an accurately fitting socket can be modelled

Artificial limbs have been improved greatly as a result of experience gained in the two world wars and are vastly different from their ungainly and cumbersome prototypes Fibre and glued fabrics are used for the upper limb while for the lower duralumin and other alloys combine lightness and strength The modern limb is light in weight fits the stump accurately and when necessary can be fitted with ingeniously controlled joints Thus an artificial knee joint is generally fitted with an adjustable friction brake and with a powerful return spring which brings the leg piece forwards in walking but is put out of action for sitting while an artificial ankle joint gives the foot a limited range of cushioned movement and imparts elasticity to the gait

The bucket or socket is generally made of leather or stainless metal perforated for lightness and ventilation The weight of the body is rarely borne by the end of the stump but on the conical surfaces of the limb and on bony pressure points In leg amputations for example the weight is distributed over the sides of the stump and the bony points at the knee in thigh amputations on the cone-shaped upper thigh and the ischial tuberosity Leg prostheses are held by a gaiter above the knee while thigh prostheses are held in place by a pelvic band sometimes supplemented by shoulder straps

AMPUTATION OF THE FINGERS

Most amputations of fingers are for injuries or for stiffness resulting from sepsis They are therefore required most often in manual workers and since the loss of even a part of a finger may cause severe incapacity the economic significance of the subject cannot be exaggerated

Choice of Site for Amputations—Formerly the rule was that no portion of a digit should be sacrificed needlessly the amputation was performed at the most distal site possible

In *the thumb* this rule still holds good However short a thumb stump and however stiff and scarred provided it can be opposed towards the palm it is still of immense value in conjunction with the fingers Thus in the thumb every possible centimetre of the digit should be saved even if no skin is available to cover it for this defect can readily be remedied by skin grafting

In *the fingers* on the other hand the conditions differ Amputation through the terminal phalanx or disarticulation at the terminal joint leaves a stump of excellent function while even an amputation through the second phalanx sometimes gives a useful stump but at more proximal levels it is often wise especially in the index finger, to sacrifice the digit Where all four fingers are involved, however, as much of each as is possible should be preserved, for even short stumps of the proximal part of the first phalanges have a certain value particularly if the thumb is intact

In the *index finger* amputation higher than the middle of the second phalanx leaves a short stump of little value and very apt to get in the way The stump is the site of no tendinous insertion except the weak interossei and even if some movement is retained by careful suturing of the cut tendons over the extremity of the divided

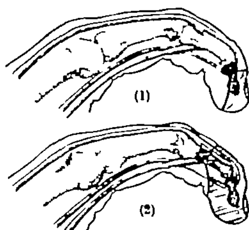


Fig. 14
Amputation of finger (1) at distal joint, (2) through middle phalanx, showing skin incisions employed.

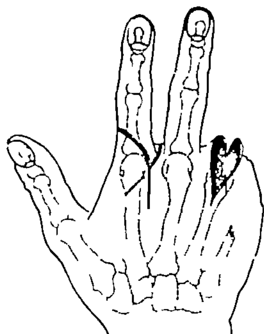


Fig. 15
Amputations through metacarpal bones, showing skin incisions and level for division of bones.

bone the patient generally prefers to make use of the middle finger holding the index stump awkwardly in mid-air where it is very prone to injury In such cases many surgeons now prefer to sacrifice the first phalanx and also the metacarpal head thus leaving a narrow but shapely hand in which the middle finger will readily assume the functions of the index

In *the middle and ring fingers* the conditions are somewhat different for here a short stump is not in the way and serves a useful function in keeping the intact fingers properly aligned and lending strength to the grip In these fingers therefore amputation may usefully be per formed as high as the middle of the first phalanx If however the whole finger must be sacrificed it is as well to remove also the head of the metacarpal bone thus allowing the adjacent intact fingers to fall together and giving a good looking and useful narrow hand.

In *the little finger* the sites of election are the same as in the index

if the second phalanx cannot be preserved the entire finger and metacarpal head should be sacrificed

Technique of Finger Amputations—General anæsthesia is usually desirable though amputation through the distal phalanges can be performed under regional anæsthesia induced by infiltrating the base of the finger with novocaine The whole hand is sterilised and adjacent fingers are separated by gauze retractors held by an assistant If skin is available a long palmar skin flap should be fashioned (Fig 14) so that the end of the stump will be covered by tough skin accustomed to pressure When however as often happens sufficient

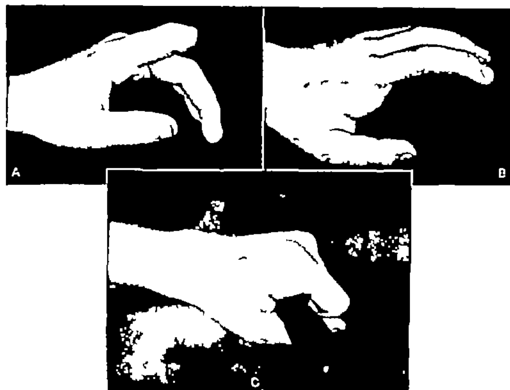


FIG 16

Amputation of index finger A, Primary amputation through middle phalanx. The stump is stiff and painful and prone to injury B Secondary amputation through metacarpal bone. C, End result; a useful hand with very little disability

tissue is not available for this purpose any available skin may be used In some cases *e g* a clean cut through the distal joint of the finger where any further shortening of the finger will cause greatly increased functional impairment it is often possible to avoid the need for cutting flaps by using a Thiersch graft to cover the end of the stump

When flaps are used they should be of full thickness and cut neatly to form a smooth rounded stump The bone should be cleared of periosteum and divided cleanly with a bone cutter or fine saw taking care to avoid splintering Hæmostasis is then secured and the skin edges are closed with fine silkworm gut Drainage is unnecessary

To encourage early movement—a principle of primo importance in the management of all hand lesions—the dressings should be limited to the affected digit and the use of a sling should be forbidden

In amputation through a metacarpal a racket incision is most satisfactory (Fig 1 b) In the case of the index finger the incision is so fashioned as to provide a long lateral flap to cover the end of the stump In the case of the middle and ring fingers the racket incision should be planned so as to leave an adequate amount of skin at the web and to remove a wedge of skin on the palmar aspect to avoid unsightly puckering at this point The incision is deepened on the dorsal aspect and the extensor tendon exposed and divided at the level of the metacarpal neck The distal part of the metacarpal is exposed by division of its periosteum (thus in the case of the index and middle fingers, preserving the short adductor origin) and divided with a bone-cutting forceps The digit is then removed

AMPUTATION THROUGH FOREARM

When the injury is such as to leave no portion of the hand intact the amputation may be performed at the wrist or in the lower third of the forearm

Amputation at the wrist was advised formerly in order to conserve pronation supination but since the wearing of a prosthesis inevitably prevents this movement its conservation is clearly superfluous The stump moreover is apt to be cold and of poor vascularity while its length is a source of difficulty to the limb maker for an artificial hand or hook projects far in comparison with the sound side and is therefore unsightly Accordingly an amputation in the lower third of the forearm is preferable It is performed with the forearm fully supinated. Anterior and posterior flaps are cut and these should include the deep fascia The length of the two flaps should equal one and a half times the diameter of the forearm at the point of bone section The muscles should be divided long—about 1¼ in. below the site of bone section. The periosteum is then elevated the interosseous membrane divided and the bones sawn across the radius first as it is the more mobile bone When hæmostasis has been secured and the nerves dealt with the muscles and tendons are sutured over the ends of the bones and the wound closed Drainage is usually advisable for forty-eight hours The stump should be fixed on a splint supinated till healed to guard against cross union

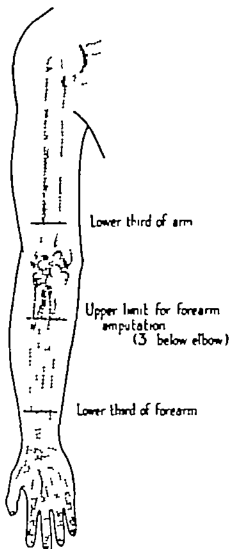


FIG. 1
Sites for amputation in upper limb.

Amputation higher in the forearm is performed in similar fashion, and will give a good stump at any point up to 3 in from the elbow A stump shorter than this is difficult to fit with a prosthesis as the biceps tendon is apt to displace the socket when the elbow is flexed In such cases an amputation above the condyles of the humerus is preferable

AMPUTATION THROUGH THE ARM

Disarticulation at the elbow leaves a bulbous stump too long to permit the fitting of an artificial joint at the natural level and is therefore inadvisable

Amputation immediately above the condyles is the operation of choice If amputation at a higher level is unavoidable all possible length should be conserved Even a 1 in stump is preferable to a disarticulation as the head of the humerus prevents unsightly flattening of the shoulder region

Amputation in the lower part of the arm is performed with the limb abducted to a right angle A tourniquet is used Anterior and posterior skin flaps of equal length give a terminal scar Since the skin of the arm is mobile and elastic the combined length of the flap need measure little more than the diameter of the limb at the point of bone section The muscles are divided about 1½ in below the level of bone section and subsequently stitched together over the bone The vessels (brachial and profunda arteries basilic and cephalic veins) and the nerves (median radial ulnar and medial cutaneous) are dealt with in the usual manner Finally the skin is sutured with especial care to obtain an unpuckered scar

Amputation in the upper part of the arm and disarticulation at the shoulder are best carried out through the anterior or racket incision described by Spence The limb is held abducted slightly and rotated laterally and bleeding is controlled by digital pressure on the sub clavian artery as it crosses the first rib The incision starts from a point lateral to the coracoid process and passes down the arm in the interval between the deltoid and greater pectoral muscles The next step is to dissect the medial flap backwards and divide the insertion of the pectoralis major thus exposing the main vessels which are thereupon ligated The circular part of the incision can now be made On the lateral aspect the deltoid muscle is cut close to its insertion and elevated The deeper muscles are then divided at an appropriate level the humerus divided and the amputation completed in the customary manner

INTERSCAPULO-THORACIC AMPUTATION FOREQUARTER AMPUTATION

This major amputation is indicated but rarely and mainly for sarcoma of the proximal end of the humerus or scapula It involves removal of the scapula and the lateral part of the clavicle as well as the upper extremity

The posterior method devised by Littlewood is most satisfactory

and if conducted deliberately it can be effected with little blood loss and practically no shock

The patient lies semi prone, supported on sandbags, with the affected arm overhanging the side of the table An incision is made along the lateral two thirds of the clavicle, then over the shoulder and down to the inferior angle of the scapula The medial skin flap is raised and the muscles attaching the scapula to the trunk—trapezius, levator scapulæ, rhomboids, serratus anterior and latissimus dorsi—are divided At the upper end of the incision the clavicle is freed and divided with a Gigli saw immediately lateral to the attachment of the sternomastoid.

The scapula can now be swung forwards and the weight of the arm pulls it away from the chest, giving good exposure for the rest of the dissection

The axillary vessels and the brachial plexus are now exposed from behind The vessels are ligated and divided under direct vision and the nerves are cut through after preliminary blocking with local anæsthetic

The arm and shoulder girdle are now drawn backwards to give access to the front of the shoulder, and the incision is completed by dividing the skin from a point over the coracoid process down across the axilla to the lower end of the initial incision All that now remains is to divide the pectoralis major at a convenient point and the limb is then removed It is generally advisable at this stage to strip the axillary fat and lymph glands downwards and remove them Finally the wound is closed by skin sutures

A prosthesis may be fitted subsequently to restore the symmetry of the shoulder region.

AMPUTATION OF THE TOES AND FOOT

The great toe may be amputated through the terminal phalanx at the distal joint or at the metatarso-phalangeal joint The other toes should be removed at this last-mentioned level as a short stump is useless and may be troublesome

Amputation of the terminal phalanx of the hallux is a simple operation and leaves no disability It is indicated for deformities of the nails which have resisted simple methods of treatment, for subungual exostosis and for chronic infections of the nail bed. The technique is similar to the corresponding procedure in the fingers. The dorsal incision is made over the base of the phalanx and opens into the distal joint The knife is taken through the joint and then carried distally to form a long plantar flap No ligatures are required and the wound is closed without drainage

Amputation at the metatarso-phalangeal joint is indicated mainly for injuries and for such deformities as a severe hammer toe especially in the case of the fifth toe Amputation of a single toe or even of two toes leaves little disability but if three digits are lost the remaining two tend to become deformed and are better all sacrificed A racket incision is most satisfactory (In the case of the great toe the incision

is planned to give a generous flap of skin on the medial side an ensure that the scar will be free from pressure by the shoe) incision is deepened on the dorsal aspect and the joint is ent The common difficulty is to find the joint, which lies much fu proximally than at first sight appears—about an inch proximal to web The exact position of the joint can be displayed during course of the operation by maintaining traction on the toe alternately flexing and extending it

When the toe has been removed and hæmostasis has been sec the wound is closed without drainage

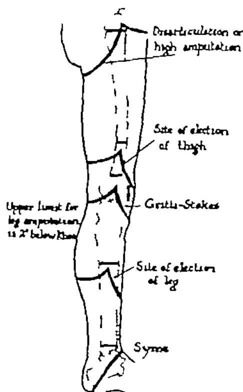


Fig 18

Sites for amputation in lower limb.

Amputations through the Fo Lisfranc s amputation at the t metatarsal joint is indicated occa ally for severe injuries of the fore but it is seldom that ther sufficient skin available for the plantar flap which is required W practicable it gives a good stump subjected to weight bearing and ordinary boot can be worn wi cork insot Other procedures, Chopart s amputation at the tarsal joint are no longer regarde satisfactory

Lisfranc s amputation is ca out through a short convex d flap and a long plantar flap w extends forwards to the metat heads The flaps are elevated the joint is entered on the lat side behind the prominent bas the fifth metatarsal bone S difficulty is usually experienced freeing the base of the second m tarsal, which is wedged between cuneiforms and it is often sim to divide the base of the metatarsal or the prominence of the i cuneiform

Syme's Amputation at the Ankle—In this classical amputat the bones are divided $\frac{1}{4}$ in above the ankle joint the stump b covered with a flap of skin from the heel In Syme s day the amp tion was a valuable one for it provided a broad bearing surface cove with thick skin on which the patient might begin to walk withi month or two of the operation and which required no other prosth than an ordinary boot the toe part of which was filled with cork.

At the present time however Syme s amputation is less satisfact unless the patient is prepared to do without an artificial limb for constricting effect of the prosthesis sooner or later leads to circulat disturbance with pain and sometimes ulceration of the stump Inde in three cases out of four later re-amputation proves necessary

For this reason and since equally good immediate results and much better late results can be obtained by a mid leg amputation Syme's operation is now performed less often than formerly

The modern technique which differs in detail from Syme's original method, is as follows The patient is placed with his foot projecting beyond the table his calf supported on a sandbag A tourniquet is applied to the thigh The incision is an ellipse passing from the tip

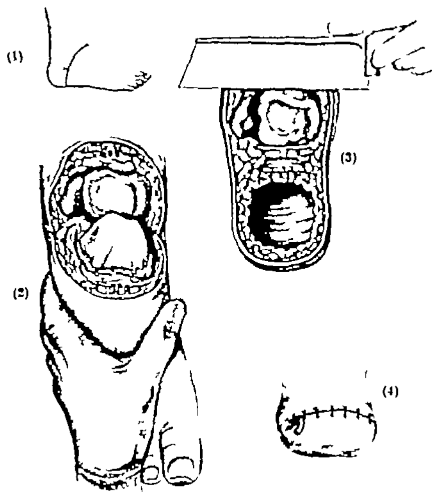


FIG 10

Syme's amputation.

(1) The incision. (2) The ankle joint opened and the foot depressed prior to shelling the calcaneus out of the heel flap. (3) The lower ends of tibia and fibula being removed. (4) The heel flap brought forward and sutured.

of the lateral malleolus across the front of the ankle about 1 in above the joint then down and back to cross the under aspect of the foot about 1 in in front of the point of the heel

With the foot forcibly plantiflexed the anterior part of the incision is deepened dividing the extensor group of *tendons* and the anterior capsule of the joint The collateral ligaments are also divided and further plantiflexion opens up the joint and permits division of the posterior capsule The tendo Achillis can now be exposed at its insertion into the calcaneus and divided

The next step is to shell the calcaneus out of the heel flap This is the most difficult step of the operation for the skin is firmly adherent and the enucleation must be effected by means of a knife At this stage special care is necessary to avoid damage to the posterior tibial artery which passes down in close relation to the posterior capsule of the ankle and the medial aspect of the calcaneus Damage to this vessel at a point proximal to its medial calcanean branches imperils the blood supply to the heel flap

When the calcaneus has been shelled out and the foot removed the skin flaps are retracted and the lower ends of tibia and fibula cleared The bones are divided with a saw about ¼ in above the ankle joint and care must be taken to ensure that the saw cut is exactly transverse The vessels (medial and lateral plantar and dorsalis pedis arteries and the saphenous vein) are ligated and the nerves (superficial peroneal and tibial) are dealt with in the usual way Finally the heel flap is brought forward over the end of the bones and sutured A strip of rubber should be inserted at one end of the wound to drain the dead space within the heel flap

AMPUTATION IN THE LEG

This amputation is indicated for severe injuries for tuberculosis of the ankle where conservative methods have failed and for malignant tumours of the foot and ankle region When properly performed it gives an excellent stump which can readily be fitted with a prosthesis.

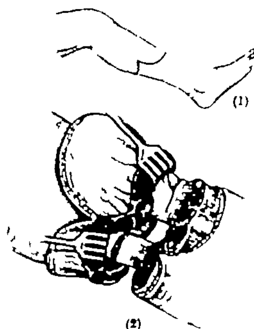


Fig 20

Mid leg amputation. (1) The incision (2) Flaps reflected, muscles divided and retracted, fibula divided at a higher level, and tibia being sawn across.

The site of election is 6 in below the knee Amputation at a lower level should not be performed for the thin delicate skin of the shin (so liable to ulceration in the intact limb) is quite unsuitable for covering the stump If the amputation must be performed at a higher level than the site of election as much length as possible should be conserved but a stump containing even 2 in of tibia is effective in controlling the prosthesis If less than 2 in of tibia is available it is generally better to amputate above the knee

It is preferable to use a long anterior and short posterior flap (Fig 20) though others may be used to conform to the available skin The muscles of the leg are divided cleanly across at the level of bone section they retract very little and are not sutured over the bone ends The interosseous membrane is also divided at this level The next step is to clear the fibula high up by incising and elevating its periosteum The fibula is then sawn across at a point ½ in above the proposed line of section of the tibia to avoid projection of the fibula against the skin flap In high amputations the whole upper end of the fibula should be excised The tibia is divided transversely and its sharp anterior angle is removed by an oblique saw cut—in practice the oblique cut should be made first while the tibia can be held steady

When the limb has been removed the anterior and posterior tibial arteries and the saphenous veins are ligated and the tibial and peroneal nerves are dealt with in the usual manner The skin is then closed with drainage by a strip of rubber dam Finally the limb should be immobilised on a back splint to prevent jerking and to guard against flexion contracture at the knee

The artificial limb applied after this amputation includes a socket which is fitted accurately to the stump and takes the body weight from the bony points round the knee No weight is borne on the end of the stump

SUPRACONDYLAR AMPUTATION

In the *Gritti-Stokes amputation* the femur is divided immediately above the condyles The patella is retained in the anterior flap and divested of its cartilage is applied to the end of the femur The amputation is not now practised as often as formerly as the length of the resulting stump makes it difficult to fit a prosthesis with a knee joint at the natural level. It has however one great advantage in that the anterior skin flap retains a copious blood supply from the patellar anastomosis Moreover it is a simple amputation causing little shock For these reasons it is particularly suitable for cases of senile gangrene where the immediate results of amputation count for more than the subsequent fitting of a prosthesis whose use by an elderly person is problematical.

The anterior skin flap is outlined by a broad U-shaped incision which crosses the front of the leg immediately above the tibial tuberosity The incision is deepened into the joint and the whole anterior flap comprising the skin and the patella with its tendon and lateral expansions is then lifted and turned upwards exposing the lower end of the femur At this stage the articular surface of the patella is shaved off with a saw and the synovia membrane of the suprapatellar pouch is dissected out and removed

The posterior skin incision is now made the flap being about half the length of the anterior one The hamstring muscles are divided as low as possible to allow for retraction and the popliteal vessels and tibial and peroneal nerves are also divided

Both flaps are now retracted to expose the lower end of the femur which is cleared of periosteum and divided immediately above the condyles When blood vessels and nerves have been dealt with in the usual manner the patella is applied to the cut end of the femur and fixed in place by suturing the patellar tendon to the hamstring muscles Care must be taken that the patella is held in position firmly so that it will not be dislodged by contractions of the quadriceps muscle Finally the skin is closed with drainage for twenty four hours

AMPUTATION IN THE THIGH

This amputation is indicated for severe injuries for tuberculosis of the knee when conservative measures have failed for acute in*fections including gas gangrene for primary malignant tumours and* for arteriosclerotic gangrene

When possible the femur should be divided in its lower third When a higher amputation is unavoidable all possible length of bone must be conserved Long anterior and short posterior flaps are most satisfactory in order to leave a posterior scar or an elliptical incision may be used leaving more skin in front than behind The combined length of the flaps should equal one and a half times the diameter of the limb at the point of bone section

The muscles of the quadriceps group do not tend to retract much and are divided obliquely down to the bone The hamstrings which retract considerably are generally divided at a *lower level. The bone* is cleared the muscles protected and the saw cut made Vessels and nerves are dealt with in the usual way Some surgeons cut all the muscles short and leave them unsutured but generally to provide a more shapely stump and to prevent adhesion of skin to bone it is preferable to suture the hamstrings to the quadriceps muscles over the *end of the bone*

The artificial limb worn after thigh amputations takes the body weight from the sides of the conical stump and from the tuber ischii. The limb is retained in place by means of a pelvic band supplemented by shoulder straps

DISARTICULATION AT THE HIP

This high amputation is indicated for extensive injuries for sarcoma of the upper end of the femur and occasionally for severe infections of the thigh It is a severe operation and may be accompanied by much loss of blood and shock

The most satisfactory method is Kelley s in which the muscles are divided close to the pelvic bones and the stump is covered by skin derived from the gluteal region

The anterior incision is made about 2 in below and parallel to the inguinal ligament *and is carried laterally After the femoral vessels* have been isolated and divided the muscles in the anterior part of the thigh are divided along the same line A long posterior skin flap is then

CHAPTER V

AFFECTIONS OF BLOOD VESSELS

GENERAL CONSIDERATIONS

(a) ANATOMY AND PHYSIOLOGY

BLOOD vessels in all parts of the body are supplied by vasomotor fibres which are derived from the sympathetic division of the autonomic nervous system Connector fibres pass from the vasomotor centre in the medulla oblongata to cells in the lateral horns of the spinal cord between the first thoracic and the second or third lumbar segments of the cord from these cells the preganglionic fibres arise and pass by way of the white rami communicantes to the sympathetic trunk in one of the ganglia of which they form a synapse with ganglionic cells which in turn give rise to the post ganglionic fibres The post-ganglionic fibres join the spinal nerves through the grey rami communicantes Certain blood vessels receive parasympathetic vasomotor fibres which are distributed through cranial and sacral nerves but so far as is known there are no parasympathetic vasomotor fibres to vessels of the limbs

Instead of using an anatomical division into parasympathetic and sympathetic fibres it is of advantage to classify autonomic nerve fibres according to the chemical substance which is released at the fibre ending on stimulation and by which the effects of the stimulus are transmitted across the synapse or to the effector cell Cholinergic fibres are those in which the transmitter is acetylcholine adrenergic fibres where the transmitter is adrenaline or some closely related substance All preganglionic fibres all post-ganglionic parasympathetic fibres and some post-ganglionic sympathetic fibres (those for instance to sweat glands) are cholinergic but the great majority of post-ganglionic sympathetic fibres are adrenergic

The blood vessels of the extremities are innervated by adrenergic post-ganglionic sympathetic fibres A layer of sympathetic fibres continued from the aortic plexuses invests the walls of the largest arteries for instance the subclavian axillary iliac and femoral but all the other arteries the arterioles the capillaries and also the veins receive their sympathetic supply from fibres which leave the somatic nerves at different levels to reach the blood vessels. The fibres to the skin vessels travel with the cutaneous sensory nerves those to the muscle vessels with the motor nerves The great majority of the sympathetic fibres to the skin vessels are constrictor in action though

there may be some dilator fibres. Quite recently it has been shown (Barcroft and Edholm 1940) that the muscle blood vessels receive both constrictor and dilator sympathetic fibres. The blood vessels are maintained in a state of tone by constrictor impulses from the medullary centre the activity of which is constantly modified by nervous chemical and thermal influences. For example inhibition of vasoconstriction causing widespread vasodilatation in skin and muscle occurs when the body is warmed or during fever probably through an action of the raised blood temperature on the medullary centre. The skin vessels are dilated during sleep. Vasodilatation by active dilatation as well as inhibition of constriction occurs in muscles but not in the skin during a faint and is responsible for the profound fall of blood pressure. Increased vasoconstrictor tone of central origin is seen in many conditions for instance after a large hæmorrhage and is reinforced by secretion of adrenaline and probably by other humoral agents acting peripherally. constriction affects all vessels even the veins.

Many peripheral mechanisms alter the calibre of the blood vessels. The well known responses of the skin vessels to mechanical stimulation and injury such as the "triple response" and the "axono reflex" need not be described here but mention must be made of "reactive hyperæmia" which follows occlusion of the arterial supply and even occlusion of the veins. It is best seen after the release of a tourniquet when the skin flushes as a result of dilatation of the arterioles and of the minute vessels; the dilatation is probably produced by a dilator substance which is formed during the period of occlusion. Exposure to local heat or cold produces somewhat complicated reactions and in this connection an interesting observation is the presence in the skin of the digits of arteriovenous anastomoses which open or close at different levels of external temperature and which are under sympathetic nervous control. An important peripheral mechanism for dilatation of muscle vessels is the formation of metabolites during muscular exercise and it is to be noted that the increased blood flow in muscles during exercise is many times greater than can be obtained by inhibition of vasoconstrictor tone alone.

(b) Sympathectomy

The operation of sympathectomy in which the sympathetic fibres to an extremity are severed is designed to provide maximum vasodilatation in cases of deficient blood supply to an extremity. The details of the operations for sympathetic denervation of the upper and lower extremities will be described later in this chapter. The operation is of course useless if the vessels are rendered incapable of appreciable dilatation by structural alterations in their walls; thus the capacity of the vessels to dilate must be tested beforehand. When the vessels are healthy sympathectomy produces an immediate striking increase in the skin blood flow and in the resting blood flow through muscles which is almost doubled. Unfortunately these effects are not permanent. The forearm blood flow which is mainly through muscle returns to

the normal level a few weeks after sympathectomy and the skin flow shows the same tendency though it may remain somewhat increased for months or even for years. The reason for this regression is not yet clear. Sensitisation to circulating adrenaline may follow denervation of blood vessels and particularly degeneration of the post-ganglionic fibres. For this reason section of preganglionic fibres has been preferred to removal of ganglia and cell stations. Sensitisation however is found after preganglionic as well as after post-ganglionic section and it is probably less important than it was once thought to be. Regeneration of the severed fibres is known to occur but the functional capacity of regenerated fibres is usually poor. Return of tone in the vessels cannot be satisfactorily explained in all cases by sensitisation or by regeneration of nerves and at present it may be assumed to be an intrinsic property of the vascular musculature. It should be mentioned here however that the usual operations on the sympathetic chain do not always sever all sympathetic pathways to the limbs. Another drawback of sympathectomy is that dilator fibres are divided as well as constrictor fibres in the case of muscle vessels at least. In spite of all these limitations however sympathectomy is a measure of considerable value in the treatment of some vascular disorders of the limbs.

(c) Special Examinations and Tests

Skin Temperature Changes.—A rough indication of the capacity of the skin vessels to dilate is obtained by estimating the rise of skin temperature which follows inhibition of vasoconstriction. The affected part is exposed to a cool and constant room temperature and the skin temperature is recorded at short intervals by a thermocouple arrangement. After a control period vasoconstriction is inhibited by one of several methods. The most convenient is vigorous body warming using immersion of unaffected limbs in hot water (40 to 45 C), a heating cage over the trunk, hot water bottles and hot drinks (a rapid rise of the skin temperature of a digit to about 34 C after twenty to thirty minutes body warming indicates full normal vasodilatation). Another method is to paralyse sympathetic fibres by procaine injection: the fibres can be infiltrated in the sympathetic trunk or in large peripheral nerves or by spinal anaesthesia in the case of the lower extremity. Vasoconstriction can be inhibited also by intravenous injection of tetra-ethyl-ammonium chloride or bromide or of some other ganglionic blocking agent such as the methonium compounds. These substances block synaptic transmission in all autonomic ganglia and thus have rather complicated effects for the purpose of this test.

Reactive Hyperaemia Test.—The reactive hyperaemia test of Lewis is a simple and fairly useful test. While the limb is kept warm the circulation is shut off for several minutes by a pressure cuff on the upper arm or thigh. On release of the pressure the skin flushes and the blood flow can be judged roughly from the intensity and rapidity of spread of the flush. The flush spreads over a healthy limb within about five seconds but when the vessels are diseased it may take a minute or longer to reach the digits.

Measurement of Volume Flow—The quantity of blood flowing through part of a limb can be estimated by the method of Hewlett and Van Zwaluwenburg (1909) The limb volume is recorded in a plethysmograph and a cuff is applied proximally whereby the veins can be occluded From the increase of limb volume which follows compression of the veins the volume flow may be calculated The flow through the hand may be regarded as mainly skin flow and the flow through the forearm (the circulation to the hand being occluded) as mainly muscle flow the method has been adapted to measure flow through the bones This method is more informative though more complicated than the other tests and it gives a fairly precise quantitative estimate of blood flow

Arteriography is employed to determine the site of arterial occlusion the distribution of collateral channels the presence and size of aneurysms or arteriovenous communications Ten to 20 ml of 50 per cent diodone solution are injected as rapidly as possible into the main artery while the vessel is occluded by pressure above the site of injection and radiographs are taken when the injection is almost completed and again a few seconds later Injection may be percutaneous or after operative exposure of the artery under anæsthesia and the technique may be modified for certain purposes

Venography is a similar examination of veins and has been used to demonstrate the presence of thrombosis in the deep veins of the legs

Oscillometry—The pulsations of the main artery of a limb can be examined by the Pachon oscillometer and the level of an arterial obstruction can often be determined with fair accuracy

INJURIES OF ARTERIES

The arteries considered here are the larger trunks particularly the main arteries of the extremities and the type of injury is that in which damage is more or less limited to the artery and neighbouring structures the limb is not so severely shattered or mangled as to require immediate amputation Arterial injury may be produced in many different ways but most often it is the result of a penetrating wound In warfare the common agent is a high velocity missile such as a rifle bullet and the missile may damage the artery by its lateral concussive action without actually touching the vessel. The artery may be thrown into spasm it may be contused partly divided or completely divided.

Spasm is usually a result of lateral concussive action but may follow crushing injury or the use of a tourniquet Spasm is variable in degree in extent and in duration In most cases it does not completely occlude the lumen it affects no more than a few inches of arterial wall and it lasts only for a few hours—rarely more than twenty four Spasm therefore is not a common cause of gangrene except when many collateral channels are severed

Contusion is a result of more severe or more direct injury The inner coats of the vessel may be torn and thrombosis may occur at once or later if the thrombus becomes detached it produces embolism

more distally Another later development is necrosis of the vessel wall which is followed by the formation of a false aneurysm or by secondary hæmorrhage

Partial division is accompanied by bleeding into the tissues when an arterial hæmatoma is formed which may later become a false aneurysm or by bleeding to the exterior *Sometimes however the* companion vein is also opened and an arteriovenous fistula is created the communication between artery and vein may be direct (aneurysmal varix) or indirect through the medium of a sac (varicose aneurysm)

After *complete division* both ends of the artery as a rule retract bleeding though initially often copious stops spontaneously If however retraction of the ends is prevented bleeding continues

Spasm contusion with thrombosis and complete division of an artery are often associated with *ischæmia* of the tissues supplied by the vessel and the risk of ischæmia is much greater in the case of some arteries—for instance the popliteal the common femoral and the axillary—than of others

Careful and frequently repeated observations are necessary to determine the threat to the vitality of the limb Indications of serious *anoxia are coldness and a mottled pallor and cyanosis of the skin*—sometimes with blister formation—absence of distal pulses and gross impairment of nerve conduction pain is common though not invariable and is often intense It is now recognised that tissues tolerate anoxia better if they are kept cool and their metabolic needs thus reduced Recovery can be ensured only by the timely development of an adequate collateral circulation which is supplied at first by existing anastomotic channels and later also by the enlargement of numerous small vessels

Partial division does not completely interrupt the flow of blood through the arterial lumen and therefore ischæmia is not an immediate result though it may appear subsequently when *a false aneurysm* begins to exert pressure

TREATMENT

The most serious consequence of injury to a large artery is hæmorrhage and the danger to life takes precedence of all other considerations The first step therefore is to control bleeding and the best method is the application of a firm elastic dressing to the wound If this fails *it may be possible to clamp the artery with an* artery forceps or even to apply a ligature but if not a tourniquet must be employed The next step is to replace lost blood a low blood volume not only endangers life it gravely aggravates the ischæmia to which the tissues in the distal part of the limb are subjected The volume and rate of transfusion required depend upon the degree of exsanguination. Operation is indicated if the wound is large and lacerated and in all cases of severe ischæmia On the other hand, if the wound is small and the signs are those of partial division, expectant treatment is advised because some blood continues to flow through the main artery for several days and during this period a collateral circulation is developing Ultimately it may be necessary to operate

and to ligate the artery or resect a portion of it for such complications as hæmorrhage or an enlarging aneurysm, but by that time the collateral circulation may have developed sufficiently to ensure the survival of the limb

Care of Ischæmic Tissues.—The limb is immobilised in a splint all points of pressure being protected by pads of cotton wool and the limb is exposed to the air while the bed clothes are supported by a cage or cradle To cool the limb a fan blower is useful but a simpler method is to cover the skin with wet lint and promote cooling by evaporation Direct application of ice bags may injure the skin and is not recommended The danger of infection especially by anaerobic organisms must be remembered all abrasions or wounds of the skin surface and all blisters should be dusted with penicillin-sulphonamide powder and protected by sterile dressings An elevated position of the limb is sometimes advised on the ground that it lessens œdema, which may compress capillaries but there is no good evidence as yet that œdema does exert harmful pressure If elevation is used it should be not much above the level of the heart The best position is that in which the limb is most comfortable and shows the best circulatory signs That position is sometimes slightly below the heart level

The most effective method of promoting dilatation of collateral vessels is general body warming by hot water bottles and hot drinks reinforced by morphine and a sedative to ensure rest and sleep artificial warming however should be omitted if the patient is febrile Infiltration of the appropriate segment of the sympathetic trunk by procaine is now generally recommended and repeated sympathetic block by procaine is preferred to the operation of sympathectomy

Operations on the Artery.—While bleeding is controlled by a tourniquet the wound is treated in the usual way by excision of damaged tissue and extravasated blood is removed A free and thorough exposure of the artery is made great care however is exercised not to divide intact vessels which may serve as collateral channels The artery is isolated above and below the site of injury and occluded at these points by light jawed rubber-covered spring clamps or bull dog clamps or by tape the tape is drawn sufficiently tight to occlude the lumen and held by an artery forceps close to the vessel wall or it may be tied over a short length of rubber tubing which is wrapped round the vessel to protect it from severe pressure Small bore thin walled rubber tubing may be used instead of tape The tourniquet is then removed and hæmostasis secured the ends of all torn or severed vessels are ligated *whether they are bleeding or not* The injured artery is examined The presence and position of a hole if not at first obvious can be confirmed by momentary release of the proximal clamp If no wound is present the clamps are removed

When the artery is in spasm all that is necessary is to irrigate the area with warm saline solution Stripping the peri-arterial coat or injecting it with procaine is useless and may be harmful If the artery is moderately bruised but pulsating a portion of fascia or muscle is stitched over it as a safeguard against subsequent necrosis and hæmorrhage Absence of pulsation indicates thrombosis and the

thrombus should be removed the clamps are again applied the artery *incised, the clot removed by suction and the incision sutured* Heparin is administered for the next forty-eight hours Gross contusion of the artery is very likely to be followed by necrosis and calls for resection of the affected portion If however pulsation is present resection may be postponed for one or two days

When partial division of the artery is found it may be possible to close the opening by suture without producing undue narrowing of the lumen longitudinal wounds are more easily sutured than oblique or transverse wounds In fact however suture is often not feasible and the usual practice is to ligate the vessel after resection of the injured segment Ligation of the main artery in one of the 'dangerous' situations *e g* the popliteal the common femoral and the axillary will probably be followed by gangrene of the limb if much damage has been done to muscles in the vicinity In these circumstances it is justifiable to try to maintain the patency of the artery after resection of the segment the ends are joined by a vein graft with 2 vitallium cuffs (Blakemore) To prevent intravascular clotting heparin is given for about a week after operation Heparin however should not be used if other wounds are present

Complete division is treated on the same lines as partial division Only when the artery has been cleanly cut across by a sharp instrument as in stab wounds is it possible to do end to-end union even then there may be dangerous tension at the line of anastomosis Union by a free vein graft and cuffs may be tried if facilities are available In both cases heparin is required after operation Usually ligation of the divided ends is all that is possible

Surgical Procedures.—(1) *Ligation* —Non-absorbable suture material is in all circumstances preferable to catgut For arteries of medium size linen thread is strong enough but for large arteries one or two ligatures of stout silk are required To avoid rupturing the vessel coats the artery is first emptied at the site of ligature by compressing it with the fingers

(2) *Suture* —The adventitia is stripped off the area to be sutured and the lumen irrigated with 3 8 per cent solution of sodium citrate or a solution of heparin diluted with saline The suture material is *fine silk coated with soft paraffin or liquid paraffin and on eyeless* needles The edges of the wound are approximated and everted by pulling on stay sutures inserted at each end and are joined by a continuous stitch The occluding clamps are then removed Some bleeding from the line of suture is to be expected but it usually stops after pressure has been applied for a few minutes

(3) *End to End Anastomosis* —The adventitia is stripped off the ends Three equidistant stay sutures are inserted and while adjacent stays are held tight the intervening portions of the arterial walls are joined by a continuous stitch The clamps are removed and bleeding stopped by pressure The last step is to cut the stay sutures (Fig 21)

(4) *Union by free vein graft and vitallium cuffs* (Fig 22) —A vein such as the great saphenous or superficial femoral vein which is nearly equal in calibre to the divided artery is selected to provide a

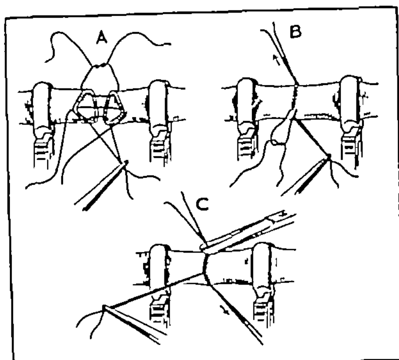


Fig 21

A, Stay sutures inserted; B suturing between stays C, cutting stays.

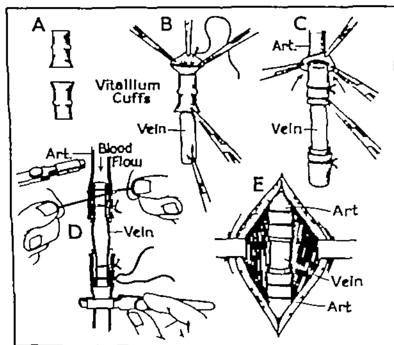


Fig 22

A, Vitallium cuffs; B, end of vein passed through cuff to be everted and tied over outer surface of cuff; C, vein-covered cuff being introduced into proximal end of artery; D junction almost completed, shown in section; E, junction completed.

graft and a portion about 3 to 4 cm longer than the gap to be bridged is isolated and removed Its lumen is at once washed with heparin solution The vitallium cuff about 1 cm long, has a tying ridge situated about its middle and a flanged end which faces the flanged end of the other cuff across the gap Each end of the vein is passed through one of the cuffs entering by the flanged end everted over the other (outer) end turned back over the outer surface of the cuff and tied by a ligature of fine silk placed behind the tying ridge Each vein-covered cuff is then inserted into an end of the artery which is tied on the cuff by a strong silk or linen ligature placed behind the tying ridge The intima of the artery is thus in contact with the everted intima of the vein. Finally close apposition is secured by a fine silk ligature placed about 2 mm from the outer end of the cuff

(5) *Administration of Heparin*—When heparin is used after the operations mentioned above it is given preferably by repeated intravenous injections The dose is regulated by the blood coagulation time which should be maintained at twelve to fifteen minutes (instead of the usual three or four minutes) The effect varies considerably in different individuals but commonly a first dose of 10 000 units followed by a second dose of 10 000 units two hours later raises the coagulation time to the desired level at which it can be kept by an injection every four hours of about 5 000 units Heparin may be given by continuous intravenous infusion of physiological saline solution containing 1 000 or 1 500 units per 100 ml and the infusion rate is regulated by the coagulation time In every case the wound is inspected frequently for signs of bleeding

(6) *Procaine Injection of the Sympathetic Trunk* (a) *Cervicothoracic Injection*—The patient lies on his side the side to be injected uppermost the head strongly flexed and supported on a pillow to prevent lateral curvature of the cervical spine Procaine wheals are made in the skin at points 4 to 5 cm from the mid line and opposite the spinous processes of the seventh cervical first second, and third thoracic vertebræ A 10 cm needle is inserted perpendicularly at each point the highest is to pass above the first rib the others between the ribs At a depth of 3 to 6 cm. the needle impinges on the rib or transverse process It is then manœuvred past the rib and at an angle of about 20° to the mid line until it strikes the lateral aspect of the vertebral body Before injection aspiration is carried out to make sure that the needle has not punctured a vessel or penetrated the pleura 5 ml of 1 per cent procaine are injected into the needle Increased warmth and dryness of the skin dilated veins capillary pulsation and in particular Horner s syndrome indicate that the sympathetic trunk has been infiltrated

(b) *Lumbar Injection*—The patient lies on his side with a pillow under the flank the side to be injected is uppermost Procaine wheals are made at points 4 to 5 cm from the mid line each opposite the upper border of a spinous process of one of the first three lumbar vertebræ Inserted perpendicularly the needle strikes the transverse process at a depth of about 5 cm It is then withdrawn and directed upwards at an angle of about 25 to the mid line About 4 to 5 cm. deeper

than the transverse process it encounters the side of the vertebral body. After preliminary aspiration from 5 to 10 ml. of 1 per cent procaine are injected through each needle.

TRAUMATIC ANEURYSM

Traumatic aneurysm is a sequel of arterial injury which ultimately requires operative treatment. In many cases the steady enlargement of the aneurysm causing pain and ischæmia demands operation within a few weeks of the injury. The site is exposed by a technique similar to that for repair of an arterial wound. If the aneurysm is very large and exposure is difficult, a two-stage operation may be advisable. At the first stage the main artery is tied proximal to and as near the sac as possible, thus reducing the size of the aneurysm considerably; at the second stage the sac can be extirpated. Before carrying out proximal arterial ligation, however, the operator must be certain that the condition is not one of arterio-venous fistula, in which proximal ligation of the artery may easily precipitate gangrene. If the aneurysm is small and saccular, the sac is opened and, if practicable, the opening in the artery is closed by suture.

ARTERIO-VENOUS ANEURYSM

Small communications between artery and vein may heal spontaneously, while some moderate-sized communications cause little trouble and may be left alone. Sometimes, however, a communication steadily enlarges over a period of years and ultimately is responsible not only for nutritional changes in the distal part of the limb but also for cardiac enlargement and even severe cardiac failure. Operation is required for the prevention of these complications but need not be done until several months have passed since the injury which produced the fistula; in this period an adequate collateral circulation will have developed.

The operative treatment depends upon the conditions at the site of injury. An indirect communication (varicose aneurysm) is often associated with much scarring and matting of tissues, and definition of structures needs a painstaking and tedious dissection. The standard procedure is to ligate the involved artery and vein above and below the fistula (quadruple ligation) and in many cases no more can be attempted. Excision of the fistula may be impossible. A direct communication (aneurysmal varix) may be more easily attacked. Until recently it has been recommended that the fistula should be approached through the vein as follows: a segment of the vein is isolated by tying the main trunk above and below the fistula and any branches entering the segment; the isolated portion of vein is then incised and from this aspect the fistulous communication is closed by suture. Experience has now shown (Paterson Ross) that preservation of the artery with ligation of the main vein may cause very undesirable symptoms of venous obstruction. Indeed it seems preferable to ligate the artery above and below the fistula and as close to the fistula

as possible while leaving the vein patent In dealing with more complicated fistulæ involving more than one artery and vein or having more than one abnormal communication the plan would be to ligate all participating arterial channels as close as possible to the fistulæ

THROMBOSIS AND EMBOLISM

Embolism may occur in the pulmonary or in the systemic circulation and in the majority of cases it is produced by the lodgment of a detached thrombus air and fat embolism also occur

Venous Thrombosis and Pulmonary Embolism

Thrombosis in the veins of the lower extremities is an unfortunate and rather a common occurrence after surgical operations after fractures of the lower extremity after childbirth or during the course of any debilitating illness *Hospital post mortem examinations* have shown that the condition is just as common among patients in medical wards as among those in surgical wards It is now accepted that post operative thrombosis usually begins in the deep veins of the leg below the knee although it often spreads to involve the deep veins of the thigh and the iliac veins It may however begin in the pelvic veins In severity the process varies from frank thrombo phlebitis (phlegmasia alba dolens) to the silent or bland thrombosis which is sometimes called phlebo-thrombosis In thrombo phlebitis there is a rapid sedimentation rate and the affected limb is swollen painful and tender the risk of massive pulmonary embolism however is not great because the clot is everywhere fairly firmly attached to the vein wall Silent thrombosis produces little general or local disturbance and is often difficult to detect but there is a serious risk of pulmonary embolism because the clot though adherent to the leg veins *may have a long upward extension which is floating* almost free in the thigh veins and is readily detached Recent investigations suggest that silent thrombosis may develop into phlegmasia alba dolens when the extending clot increases in size adheres to the wall of the femoral vein and blocks the vein Thrombosis frequently affects both lower extremities but in both limbs it begins in the leg veins

Thrombosis is most liable to occur in patients who are elderly and feeble especially if they are also obese and in those with cardiovascular disease or varicose veins Other factors have been suggested as predisposing to thrombosis such as dehydration tissue trauma during operation and immobility of the patient after operation it is said also that the leg veins may be compressed when the lower limbs are flaccid during anæsthesia and resting on the operating table Even the recent extensive use of antibiotics has come under suspicion

Diagnosis — Silent thrombosis is not easily detected though often it may be suspected from certain features such as a slight rise of temperature and pulse-rate without obvious cause a complaint of stiffness or cramp in the calf muscles tenderness on palpation along the calf muscles pain on passive dorsiflexion of the foot and a slight

increase in the girth of the leg and in the prominence of its superficial veins These features are not always present or definite and the first indication may be symptoms and signs of infarction of the lung showing that embolism has already occurred Some surgeons particularly in Sweden have employed venography on a large scale and have claimed that the method gives an accurate diagnosis in the earliest stages of thrombosis others however have been less successful The diagnosis of phlegmasia alba dolens is not difficult

Massive emboli which block completely the pulmonary artery are fatal within a few minutes but in most cases the block is not at first complete and the patient survives for periods as long as one or two hours on occasion the clot is driven onwards into the lungs and recovery follows At the onset of massive embolism the patient suddenly becomes faint experiences great oppression in the chest air hunger and often a desire to empty the bowels the signs are those of circulatory collapse Smaller emboli produce infarcts of the lung which should be readily diagnosed by clinical and radiological examination but in fact are often missed

Prevention of Thrombosis after Operation.—Regular active and passive exercises in bed are probably effective in prevention. They should be carried out before operation and begun as soon as practicable after operation usually the following day In some clinics ambulation within a few days even after severe operations has become a regular practice and is believed to have reduced the incidence of fatal embolism Nevertheless post-operative thrombosis and embolism are still common events and are responsible for much morbidity and prolonged convalescence

The routine use of anti-coagulants such as heparin and dicoumarin has been suggested for the prevention of post-operative thrombosis but for several reasons is scarcely feasible Most adult patients run some risk of developing the condition yet in fact a very large number escape without receiving anti-coagulants Employment of heparin on a large scale is prohibited by the expense and of dicoumarin by the demands which it imposes on hospital and laboratory staff Another disadvantage of the routine use of anti-coagulants immediately after operation is that bleeding may occur in the wound Both substances however can be used in the *treatment* of thrombosis

Treatment of Thrombosis and Prevention of Embolism—Treatment should begin as soon as thrombosis is diagnosed or strongly suspected For active treatment two methods are available (1) administration of anti-coagulants (2) ligation of the femoral vein

1 *The anti-coagulants* used are heparin and dicoumarin

The main action of heparin is that of an anti thrombin by which it inhibits the process of clotting it prolongs the blood coagulation time according to its concentration in the blood stream and the effect disappears quickly as the concentration falls In the treatment of thrombosis it is administered by repeated intravenous injections on the first day two or three injections each of 12 000 units are given during the next two or three days three or four injections each of 8 000 units with gradually diminishing doses as the condition subsides

Heparin treatment lasts about a week The *patient is encouraged to* move freely and to exercise regularly in bed after about three days he is allowed up to walk about with the affected foot and leg supported by *an elastic bandage*

Dicoumarin (3 3 methylene bis (4 hydroxycoumarin)) is a synthetic substance which prolongs the coagulation time and the prothrombin *time* of the *blood* apparently by inhibiting the formation of prothrombin in the liver Its action depends upon depletion of plasma prothrombin and is therefore delayed No effect on the prothrombin level is detected until about twenty four to forty-eight hours after the first dose Its action is prolonged and the prothrombin level remains lowered for three to seven days after administration is stopped There is considerable individual variation in response to the drug and administration must be controlled by repeated estimations of prothrombin time Clearly dicoumarin action is less easily controlled than heparin action but the drug has some distinct advantages It is given by mouth and in infrequent doses and its prolonged action is sometimes of help It can also be given intravenously as the disodium salt In treating thrombosis a first dose of 300 to 350 mg is followed by daily maintenance doses of about 100 mg each keeping the prothrombin index between 25 per cent and 50 per cent of its normal level The effect on the prothrombin level should be maintained for about ten days The necessity for estimating prothrombin time at least once daily is stressed When an immediate effect on blood clotting is desired heparin is begun and simultaneously a dose of dicoumarin is given after one or two days when the prothrombin level begins to fall heparin is stopped and treatment is continued by dicoumarin alone If bleeding occurs during dicoumarin treatment the drug is stopped and a pint of fresh blood is transfused Fresh blood supplying prothrombin is *the usual treatment* but large doses of synthetic vitamin K are also effective Dicoumarin should not be used if liver or kidney function is poor especially if there is oliguria or when prothrombin is already *deficient*

Results of the treatment of thrombosis and thrombo phlebitis by anti coagulants are generally satisfactory and a striking reduction in *the incidence of embolism* especially fatal embolism is the usual experience

2 *Ligation of the Femoral Vein* —This operation is much less *frequently employed* than before and may be reserved for the occasions in which embolism continues to occur in spite of anti-coagulant treatment The femoral vessels are exposed under local anaesthesia the *superficial femoral vein* below the junction of the profunda vein is isolated and incised a long glass tube or catheter is passed into the vein first proximally then distally and the clot is removed by suction The *vein* is divided between ligatures The deep femoral and great saphenous veins are preserved Operation on both legs at the same time is advised as thrombosis very frequently involves both legs After operation the legs are bandaged from foot to knee and movement and exercises are carried out Interruption of the normal femoral vein is said to be harmless

Treatment of Pulmonary Embolism—Massive embolism which is not immediately fatal is best treated by large doses of heparin Trendelenburg's operation—to remove the clot from the pulmonary artery—is no longer recommended and need not be described here

Air Embolism

Air may enter the circulation from wounds of large veins at the root of the neck or arm sometimes it enters from the placental veins after childbirth Death may follow quickly since the air mixes with the blood in the right side of the heart to form froth or foam and thus obstructs the pulmonary circulation Prophylaxis is the most important part of treatment During operations in the dangerous situations any opening in a large vein must be at once occluded by pressure and the operation wound is filled with saline solution until the opening in the vein is finally closed by ligature or suture

Air may enter the systemic arteries from the pulmonary veins this may happen during operations on the lungs puncture of the pleura or artificial pneumothorax Fatalities are due to air entering the coronary or the cerebral vessels Again prevention is all important and great care is required in carrying out the operations mentioned Once air embolism has developed little can be done The head should be quickly lowered as a safeguard against ascent of air into the cerebral circulation in the case of arterial embolism

Fat Embolism

In spite of much recent work on fat embolism little significant advance in treatment has been made In the great majority of cases it follows fractures or operations on bones although it has been found in burns and other conditions without obvious fracture of bone In most cases the fat which enters the circulation is probably marrow fat though there has been much speculation on other possibilities Tension at the site of fracture or injury seems to enhance the risk of fat embolism Fat globules obstruct the pulmonary circulation, producing œdema congestion and hæmorrhage in the lungs but some traverse the pulmonary capillaries to reach the systemic circulation For prevention early and efficient immobilisation of fractures is most important especially if the patient is to be transported and operations on the bones of the limbs should if possible be carried out with the use of a tourniquet The possibility of fat embolism should be remembered especially in patients with multiple fractures If transfusion is required for blood loss it must be given with great care and examination made repeatedly for signs of pulmonary œdema and a rising venous pressure

Embolism of Systemic Arteries

In arterial embolism one of the main peripheral arteries becomes blocked by a thrombus which has arisen from the left side of the heart The thrombus forms in patients with severe heart disease, usually

mitral stenosis with auricular fibrillation occasionally ulcerative endocarditis or coronary thrombosis The clot becomes lodged at the bifurcation of an artery or at the origin of a large branch Diagnosis as a rule is easy but from the point of view of operative treatment it is essential that the site of embolism should be accurately localised and for this a knowledge of anatomy and of the common sites of embolism is useful There are *signs of ischæmia and obliteration of* the pulse distal to the obstruction forceful pulsation above the obstruction and sometimes the clot can be palpated Success in restoring the circulation in the limb requires that the clot should be removed within a few hours of the onset of embolism The immediate results of embolectomy in restoring the circulation to the limb are usually dramatic and gratifying but the risk of further embolic episodes remains

Embolectomy—Local or regional infiltration anæsthesia with procaine is used because of the dangers of general anæsthesia in serious heart disease The site of embolism is exposed and the main artery is occluded above and below by rubber-covered spring clamps The adventitia is dissected with care from the site of incision into the artery The artery is opened above or below the clot which is very gently expressed Any remaining portions of clot are washed out by flushing the isolated segment with a solution of heparin in physiological saline The exposed intima is kept moist with the heparin solution and should not be touched with instruments Each clamp is momentarily released to confirm that all clot is removed the isolated segment is filled with heparin solution and the arteriotomy incision is closed as described for suture of arteries Following operation heparin is administered for three or four days by methods already described

If the occluding clot is situated at the bifurcation of the common iliac artery or of the aorta and if the patient s general condition does not permit of a direct approach under general anæsthesia then retrograde removal through the femoral artery under local anæsthesia may be tried *A long glass tube or a catheter is passed upwards from the artery and the clot is removed by suction*

DISEASES OF ARTERIES

I Peripheral Vascular Occlusion

The diseases which give rise to occlusion of the arteries are arteriosclerosis thrombo-angiitis obliterans and very rarely syphilitic endarteritis The term arteriosclerosis includes a variety of lesions which affect one or more coats of the artery Changes in the media such as calcification are frequently present and are responsible for deformity and loss of elasticity of the vessel but in the present connection it is the intimal changes which are important Thickening of the intima with or without atheroma and with or without formation and organisation of thrombi gradually narrows and finally obliterates the lumen Narrowing and obliteration of the limb vascular channels lead to chronic ischæmia of the limb and the lower extremities are much more often involved than the upper In a very large proportion

of patients who suffer from chronic ischæmia of a lower limb a segment of the main artery, the femoral or popliteal for example is found to be obliterated by thrombosis Obliterated segments of the main arteries are easily demonstrated by arteriography (Fig 23) This is a disease predominantly of elderly men, and is very prevalent in elderly diabetics but it can affect younger men in whom it may be wrongly diagnosed as thrombo angiitis obliterans Thrombo angiitis obliterans begins in young men in the thirties, progresses slowly and appears sometimes to remain stationary for long periods The striking pathological features in the artery are intimal proliferation and organised



FIG 23

Arteriogram Injection of 10 ml 50 per cent. diodone Note obliteration of lower part of femoral artery popliteal artery well filled through collateral branches.

blood clot which partly or completely occlude the lumen and inflammatory changes in the outer coats At first the brunt of the attack falls on arteries of medium size but in advanced cases the main arteries and many branches are extensively diseased isolated or migrating thrombosis is often seen in the leg veins The collateral circulation develops to a remarkable degree and many years may elapse before gangrene appears All limbs may be involved but seldom the viscera

General management of occlusive vascular disease is very similar for all types It should be impressed on the patient that the disease is a serious one which may lead to the loss of a limb or limbs or even of life and that he must obey implicitly the orders of the medical attendant Tobacco smoking is absolutely forbidden Alcohol however is allowed, since it causes vasodilatation and is often effective in relieving pain ,

elderly patients may take whisky at night in doses of 30 to 60 ml unless it is contraindicated by diabetes If intermittent claudication is troublesome the patient's activities are restricted within the limits of producing pain The patient must be particularly careful to avoid chilling not only of the extremities but of other parts of the body He should wear warm woollen gloves and socks and protect the head and neck regions Many methods of encouraging vasodilatation have been tried The most satisfactory is body warming which is done once or twice a day by applying an electric heating pad over the abdomen or by immersing unaffected extremities in water at about 42° C local heat applied to the affected extremity is dangerous and is better avoided Vasodilator drugs such as nitrites stable choline esters and papaverine have a very transient action and are of little value Drugs with a more powerful or more prolonged vasodilator action have been tried recently such as the ganglionic blocking agents (for example tetra-ethyl ammonium chloride and methonium compounds) and 2 benzyl imidazoline hydrochloride strong claims have also been made for *a* tocopherol (vitamin E) which it is suggested is an anti thrombin normally circulating in the blood stream But treatment of chronic arterial disease by any of these drugs cannot compare with sympathectomy which gives much more satisfactory and durable results

The local care of the affected limbs is very important Once a day the feet are washed and dried gently and lanolin may be applied. In cutting toe-nails and paring corns great care is required not to injure the skin Any breach of the skin surface should be treated by the medical attendant Penicillin sulphonamide powder is applied to wounds or abrasions and the patient is better kept in bed till the wound is healed The exercises recommended by Buerger are carried out several times daily The limb is raised for one minute kept horizontal for three minutes while the ankle and toes are repeatedly flexed and extended and lowered to a dependent position for two minutes While the patient is resting the limb should be supported in a position slightly below the horizontal.

Treatment of Threatening Gangrene—The patient is treated in bed preferably in hospital and by the measures already outlined in addition to alcohol and body warming morphine is usually required for severe pain Penicillin is given if bacterial infection is present and a course of heparin is advised if the acute phase of ischæmia has been precipitated by thrombosis *Intermittent venous occlusion* with the object of inducing sustained reactive hyperæmia has been given a long trial but has proved disappointing and is now generally abandoned. As a rule sympathectomy is best postponed until the collateral circulation has developed sufficiently to remove the immediate threat of gangrene or to localise the gangrenous process

Operations in Occlusive Arterial Diseases

Sympathectomy—(*a*) *Of the Upper Extremity* (Figs 24 25 26)— The aim is to divide the thoracic sympathetic trunk below the third thoracic ganglion and to sever the connections of the third and

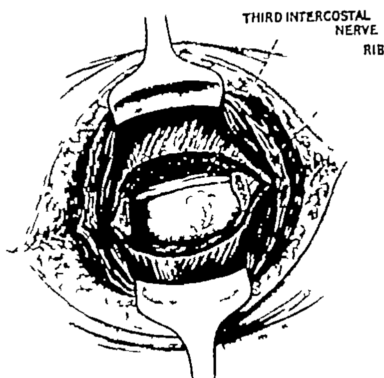


Fig. 24

Upper thoracic sympathectomy Incision; part of third rib resected Intercostal nerve and pleura exposed.

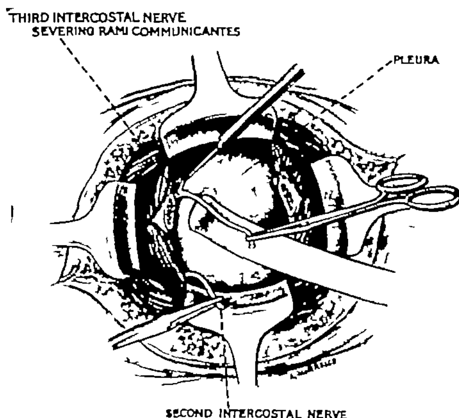


Fig. 25

Upper thoracic sympathectomy Resection of medial ends of second and third intercostal nerves, severing rami communicantes retraction of pleura.

second thoracic ganglia with the corresponding intercostal nerves The sympathetic supply to the head and face is preserved

An oblique incision is made over the posterior end of the third rib the muscles are divided or split to expose the rib about 3 in of the rib and the transverse process to which it is attached are resected the pleura is separated from the sides of the vertebral bodies and the sympathetic trunk with the third and second ganglia defined The third and second intercostal nerves are divided and the medial portions of the nerves resected severing all connection with the sympathetic ganglia The trunk is divided below the third ganglion and the upper

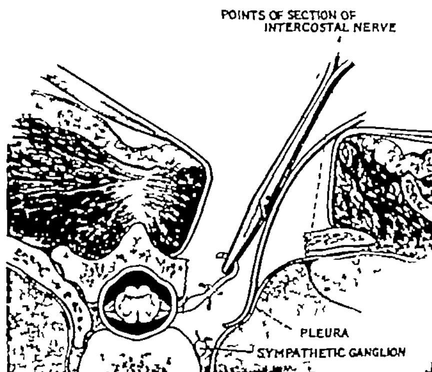


Fig 30

Upper thoracic sympathectomy Sectional view showing length of intercostal nerve resected.

end is turned upwards and buried in muscle to lessen the chances of regeneration

(b) *Of the Lower Extremity* (Figs 27 28) —The aim is to remove the lumbar sympathetic trunk from above the second lumbar ganglion to below the fourth.

An oblique or transverse incision is made about the level of the umbilicus passing from the lateral edge of the rectus abdominis muscle outwards for several inches to the flank The muscles are divided or split to expose the peritoneum which is retracted medially and forwards with the spermatic or ovarian vessels and the ureter and separated from the posterior abdominal wall The genito-femoral nerve is recognised and the sympathetic trunk is found in the hollow between the medial border of the psoas muscle and the sides of the vertebral bodies on the right side the inferior vena cava must be retracted medially to expose the trunk. Sometimes one or more lumbar vessels

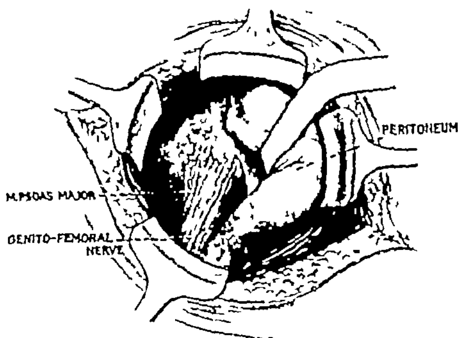


FIG. 27

Lumbar sympathectomy Incision; peritoneum retracted exposing posterior abdominal wall.

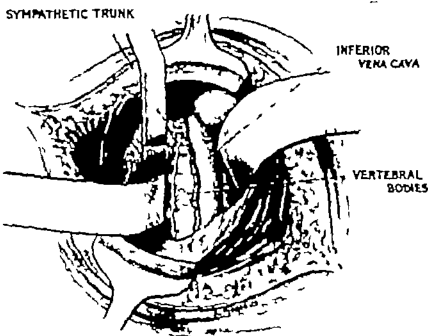


FIG. 28

Lumbar sympathectomy Retraction of medial edge of psoas muscle and of inferior vena cava exposing sympathetic trunk lying on sides of vertebral bodies.

have to be ligated and divided The trunk varies in thickness and in the distribution and size of its ganglia but is fairly easily identified

Sympathectomy is helpful in most obliterative arterial lesions but the results depend more on the site and degree of obstruction on the availability of collateral channels and on the tendency of the disease to progress than on the ætiology When the skin vessels show even a moderate capacity to dilate after body warming or sympathetic procaine infiltration the operation is advisable If relief of rest pain is obtained or even a small improvement of skin nutrition, it is well worth while When a segment of the femoral artery is obliterated the collateral channels may dilate sufficiently after sympathectomy to increase the blood flow to the leg and therefore to relieve to some extent claudication in the calf muscle On the other hand, when the vessels of the calf muscles are thrombosed as in some cases of obliterated popliteal artery claudication is not relieved In some cases of calf claudication sympathectomy gives little benefit probably because the augmentation of blood flow is far short of that required for sustained muscular activity

Denervation of Calf Muscles Achilles Tenotomy—Where sympathectomy is considered unsuitable or has failed and where the outstanding symptom is claudication of the calf muscles relief may sometimes be obtained by putting these muscles out of action This may be done either by dividing the nerves to the two heads of gastrocnemius (after exposure of the popliteal region through a suitable incision) or by performing Achilles tenotomy (see p 3[illegible]6) The tibialis posterior muscle and long flexors of the toes are of course unaffected and suffice for ordinary walking and since their blood supply is relatively copious they tend to be relatively immune from ischæmic pain

Amputation.—This is reserved for gangrene of the limb The indications sites and technique of amputation for gangrene are dealt with in Chapter IV The treatment of gangrene in some cases of thrombo-angiitis obliterans may however differ considerably from that of arteriosclerotic or diabetic gangrene In the former sympathectomy if indicated by the appropriate tests may so improve the circulation of the skin that one may wait for a line of demarcation to form and then carry out a limited amputation for instance of a digit In arteriosclerotic or diabetic gangrene amputation at or above the knee is frequently advisable and it should be done at an *early* stage before the patient s strength is reduced by bacterial toxæmia lack of sleep and pain

II Raynaud s Disease

This term should be restricted to a condition of intermittent spasm of the digital arteries with or without nutritional lesions of the digit but without primary structural changes in the arteries The affection in the great majority of cases is one of the hands and fingers It consists of attacks in which the circulation to one or more fingers is intermittently

arrested the attacks are induced by exposure to cold The mildest forms of the condition are fairly common and affect both sexes, but as a rule the attacks disappear spontaneously in middle age or remain mild and in no way disabling But in some individuals nearly all women, the condition is progressive and more serious the attacks are more easily induced and more prolonged and ultimately lead to nutritional changes such as patchy necrosis infection atrophy of skin and even sclerodactylia The circulation to the finger becomes shut down by spasmodic closure of the digital arteries and according to Lewis the fault is a local one in these arteries which respond abnormally to the stimulus of cold The malady is not primarily of nervous origin it is not due to overaction of vasomotor centres and there is no general increase of vasomotor tone A normal degree of vasoconstrictor tone may nevertheless operate to complete the obliteration of an artery which has become unduly narrowed in response to cold In the later stages of the disorder intimal thickening is usually present in the digital artery and aggravates the tendency to closure It is to be noted that Raynaud s phenomenon may appear when the arteries in the hand or higher in the limb are narrowed or occluded by arteriosclerosis thrombo-angitis obliterans or in some cases of cervical rib by emboli Such examples of occlusive arterial lesions should not be confused with Raynaud s disease

Conservative treatment alone is sufficient for mild cases and for many cases of moderate severity It may be summarised as adequate protection against cold For severer cases the precautions against chilling must be still more stringent and every effort must be made to avoid attacks The body particularly the arms should be warmly clad and in most weathers fur or woollen gloves should be worn out of doors The hands if cold should be warmed gently and slowly in warm water or by friction and not quickly for example in hot water they should be protected carefully against all forms of injury

Sympathectomy finds one of its most useful applications in Raynaud s disease It should be used for the established and disabling condition but if possible before the advanced stage of intimal thickening Sympathectomy does not remove the original defect the abnormal response of the digital artery to cold but by abolishing normal vasoconstrictor tone it makes complete closure of the vessel less likely In less severe cases attacks are prevented entirely in severer cases they become less frequent and less prolonged In the first few weeks after operation necrotic foci and other lesions usually heal and afterwards recur less often Improvement is usually permanent and after the lapse of several years most patients remain free from serious disability even when there is evidence of some regeneration of sympathetic fibres The results of sympathectomy in advanced cases with structural changes in the digital arteries are however often disappointing The foregoing account refers to Raynaud s disease of the hands and fingers In the rare cases where the feet and toes are involved the disease is milder and lumbar sympathectomy almost always abolishes attacks completely

III Other Circulatory Disorders

(*a*) **Acrocyanosis** is not a serious disorder It affects mainly young women in whom the hands and also the forearms if kept exposed by short sleeves are highly coloured cyanosed when cool red or purple when warm The coloration is due to dilatation of the minute vessels of the skin associated with constriction of the skin arterioles which are apparently abnormally susceptible to cold. It is not a primary vasomotor disorder These patients often suffer from chilblains but the inconvenience is never great enough to warrant operative treatment such as sympathectomy

(*b*) **Erythrocyanosis** *is a similar condition found almost always in* young women and affecting the legs Large patches of skin discoloration are present in the lower part of the leg and the dorsum of the foot The skin is cool but becomes tender and painful when warmed swollen and often nodular the nodules may ulcerate As in acrocyanosis the minute skin vessels are widely dilated the skin arterioles constricted.

Protection against cold both of the body and legs should give relief Patients with severe pain may have to be treated in bed In the worst cases with nodules and ulceration sympathectomy may be indicated

(*c*) **Erythralgia** (Lewis) means painful redness of the skin accompanied by extreme tenderness to touch or friction and sensitivity to heat or even moderate warmth It is common to many conditions including bacterial inflammation threatening gangrene burns and frost bite and is conspicuous at a certain stage of immersion foot ' Chronic erythralgia occurs most often in the foot and pain is so severe when the foot is warm or dependent that walking becomes impossible In some cases the cause or associated lesion cannot be determined but the older conception of erythromelalgia as a specific malady associated with vasomotor instability is probably wrong

In treatment the associated disorder is dealt with When this is obscure and the condition disabling rest in bed is essential warmth and friction are gently and gradually applied to encourage tolerance to them Lumbar sympathectomy is often very beneficial

(*d*) **Poliomyelitis,** owing to the prolonged disuse which follows extensive paralysis of a limb may be responsible for a grossly deficient circulation to the limb though the vessels are healthy and capable of full dilatation The skin is cool discoloured usually cyanotic and may develop nodules and ulcers which heal very slowly Sympathectomy produces striking improvement and ulcers heal rapidly but vascular tone is sometimes quickly regained

IV Pathological Aneurysm

Aneurysm of the aorta and of the larger arteries has become distinctly rare in recent years probably as a result of earlier and more adequate treatment of syphilis

Aneurysm of the Thoracic or Abdominal Aorta.—Conservative measures such as rest restriction of fluid and potassium iodide may be

helpful in relieving pain but they do not halt the progress of this distressing condition Palliative treatment by operation may be feasible if the aneurysm involves the ascending part of the arch of aorta or the abdominal aorta and is of the sacculated type At best, however the operation is hazardous and the results uncertain The best available method is that of Colt in which a wire wisp consisting of a number of fine steel wires is inserted into the sac through a cannula in the sac the wisp expands into the shape of an umbrella and clotting is induced This method is superior to needling (acupuncture) or the introduction of silver wire followed by galvanism (Moore Corradi method)

Aneurysm of the Larger Arteries—The nature of the operative treatment depends upon the situation of the aneurysm and the condition of the blood vessels The operation of choice is endo-aneurysmorrhaphy (Matas) which however is possible only if the arterial wall is not grossly diseased and if bleeding from the artery can be controlled by a tourniquet or by clamps applied to the main artery above and below the aneurysm The sac is freely exposed and opened and blood clots are cleared out If the aneurysm is sacculated the opening between the sac and the feeding artery is closed by silk sutures as are the openings of all branches springing from the sac and in addition the sac is obliterated by infolding of its walls (restorative endo aneurysmorrhaphy) If the aneurysm is of the fusiform type it is usual to close by suture the upper and lower orifices of the parent trunk and the orifices of all branches arising from the sac the sac walls are also infolded (obliterative endo aneurysmorrhaphy) The obliterative operation may be followed by gangrene and to obviate this risk Matas devised reconstructive endo-aneurysmorrhaphy A rubber tube is inserted into the upper and lower orifices of the parent trunk and the sac walls are sutured over the tube so as to fashion a channel corresponding to the original outline of the artery the tube is removed before the last sutures are tied and the suturing is reinforced by infolding of the sac wall

If endo-aneurysmorrhaphy is not feasible recourse must be had to ligation of the artery above or below the aneurysm Proximal ligation may be close to the sac (Anel) or at a distance (Hunter) Distal ligation is employed when proximal ligation is impossible as in aneurysm of the innominate artery Ligation may be of the main artery (Brasdor) or of both branches where it bifurcates (Wardrop) W C W

VARICOSE VEINS

The methods of treatment of varicose veins at the present time include conservative measures the injection of sclerosing solutions and ligation of the saphenous trunk.

Conservative measures are of value chiefly in the complications of varicose veins (p 99)

Simple injection of a sclerosing solution is useful for small varices and often gives a satisfactory immediate result Owing to

recanalisation however *recurrence* is common (90 per cent within two years in many published series)

High ligation combined with retrograde injection of a sclerosing solution is at present the treatment of choice in the great majority of cases In this method the saphenous vein is exposed at its point of entry into the femoral vein ligated and divided and a sclerosing solution is injected into the distal stump to initiate thrombosis Thrombosis is completed where necessary by a course of injections The procedure is reliable simple and safe and can readily be performed on out-patients

Many surgeons now supplement the high ligation by additional steps The main saphenous trunk may be exposed at several points through suitable small transverse incisions and divided between ligatures This should be done at the common sites of emergence of deep communicating veins especially in the lower third of the thigh and just below the knee In addition a large bunch of tortuous veins on the medial side of the leg may be exposed through a suitable incision and removed

SIMPLE INJECTION

The sclerosing solution is introduced by syringe and fine-bore (20 gauge) needle while the patient stands erect so that the vein is distended The needle must be perfectly sharp if difficulty is to be avoided It is generally convenient to inject the fluid in an upward direction but injections into the lesser saphenous vein at the knee should be made downwards to avoid the possibility of undiluted fluid *passing into the popliteal vein and causing a deep thrombosis.* Leakage of blood from the needle puncture is controlled by a small pad of gauze held in place by adhesive strapping The first injection is made into *the highest varix and subsequent injections at lower levels are made* at weekly intervals till thrombosis is complete The sclerosing solutions in common use include sodium morrhuate and ethanolamine oleate *(2 to 5 c c of a 5 per cent solution) the slightly greater risk of* anaphylactic reaction with morrhuate is counterbalanced by the risk of sloughing if ethanolamine escapes into the tissues Mild anaphylactic *reactions are occasionally seen and are generally* limited to giddiness and shivering Severe reactions are rare and should be treated promptly by subcutaneous injection of 0 5 c c 1 1 000 adrenalin

LIGATION INJECTION

In all save minor degrees of varicosity the main factor responsible for symptoms and for such complications as varicose ulcer is the high venous back pressure resulting from incompetence of the valves of *the saphenous vein* This back pressure can be overcome only by obliteration of the whole system which is best achieved by injecting a sclerosing solution at a high level after ligation of the main stem

Ligation injection is indicated in all cases save when the varices are small and treatment is sought only for cosmetic reasons It has been proposed that the method should be reserved for cases in which

the incision closed The patient is warned that there will be aching discomfort in the leg for a day or two and is instructed to remain ambulant despite this Skin sutures are removed in eight to ten days

The post-operative course is usually uneventful and the patient can return to work after two or three days Occasionally the inflammatory reaction to the injection is severe and there are pain tenderness and brawny induration around the vein accompanied by malaise and fever The relief of pain is immediate when an elastic bandage is firmly applied from the foot to a level above the uppermost point of tenderness and the systemic disturbance settles usually within twenty four hours



FIG 30
Incision for ligation of saphenous vein at groin

Other complications are rare and are due to technical faults Alarming hæmorrhage may follow omission of *double ligatures on the proximal* stump Wound sepsis results from division of lymphatic channels especially *in the presence of an ulcer* Pulmonary embolism may result from failure to obtain an ambulatory convalescence

Results—Ligation injection, supplemented where necessary by a course *of injections gives a highly satisfac*tory result in the majority of cases There is however a minority in whom the result is unsatisfactory It is found difficult or impossible to thrombose *straight channels which stand out like cords under the skin* —a type seen most commonly in military recruits Complete thrombosis is difficult to achieve in patients who have very numerous *sacculated channels in the calf Œdema of the ankles is often dimin*ished but is seldom abolished even when thrombosis appears to be complete Exceptionally no thrombosis is achieved in any part of the saphenous system—*this is nearly always due to failure to identify the* vein and the groin should be re-explored

The recurrence rate after ligation injection is as yet unknown for sufficient data have *not been published All that can be claimed is* that the recurrence rate appears to be much lower than after treatment by simple injection It is advisable however that all patients should *be re-examined at intervals of six months* when any fresh varices can easily be dealt with by a few injections

COMPLICATIONS OF VARICOSE VEINS

These comprise infective phlebitis venous hæmorrhage ulcer *dermatitis* and chronic cellulitis

Infective Phlebitis—This common condition requires to be differentiated from thrombosis of the deep veins (p 82), for the gravity and the treatment of the two conditions are entirely different In superficial phlebitis there are pain tenderness, and brawny induration over the varices *with malaise and often pyrexia* but massive œdema is absent The danger of embolism is slight if thrombosis can be prevented from spreading to the deep veins

The treatment is to apply firmly an elastic adhesive bandage from the foot to a level a few inches above the highest point of tenderness and to keep the patient ambulant The relief of pain is immediate and the systemic disturbance subsides within twenty four to forty-eight hours The pressure of the bandage maintains the vein walls in apposition and hinders the spread of infection Ambulant convalescence maintains a brisk circulation in the deep veins and minimises the danger of deep thrombosis The patient is encouraged to return to work within a few days When tenderness over the veins has been absent for six weeks ligation injection should be carried out if the infective phlebitis has not resulted in thrombosis of the whole saphenous system

Venous Hæmorrhage.—This results from ulceration of the overlying skin and vein wall Hæmorrhage is alarming for blood gushes out in a continuous stream as *long as the patient remains standing* The first-aid treatment is to make the patient lie down and to elevate the leg when hæmorrhage is reduced to a slow trickle easily controlled by pressure As soon as an elastic adhesive bandage can be procured it is firmly applied from the foot to above the bleeding point and the patient may thereafter be ambulant The bandage can be removed after three or four weeks, when ligation injection should be carried out

Leg Ulcer—Chronic ulcer of the leg may be due to varicose veins or occur as a late sequel of thrombo-phlebitis Often these two conditions are associated. The ulcer is usually precipitated by a minor injury or infection but its perpetuation is usually attributable to the high venous pressure that results from incompetence of the valves of the main channels Treatment therefore must combine control of the local infection by suitable applications with control of the high venous pressure by supporting bandages by recumbency or by operation on the veins Rarely a large *indolent ulcer may call for* skin-grafting

The first step in treatment is to control the local infection, especially when the ulcer is deep or spreading or complicated by cellulitis Various applications may be used. The two most generally valuable are the aniline dyes (in small ulcers which can be kept dry) and ichthyol-calamine liniment (in ulcers with much discharge) the method of applying these preparations is described on p 100 Wet applications such as eusol soaks tend to make the skin sodden and are better avoided as are ointments and preparations in an oily base Recently the use of streptomycin has been advocated. A solution of 1 gm. to the litre *is applied on gauze* with a protective covering of tulle gras and buttressed with a thick gauze pad, the whole occluded by cellophane and supported by a crêpe bandage The streptomycin is

refreshed daily or more often by injecting fresh solution under the dressing by means of a syringe and needle

The second main element in treatment is to control the high venous pressure The most certain way of achieving this is by recumbency for several weeks with the foot of the bed elevated by a wedge under the mattress Often however it suffices to keep the superficial veins in a collapsed state by means of supporting bandages Several methods of obtaining support have been used. Elastic adhesive bandages have enjoyed a short vogue but the retention of pus and in some cases sensitivity to the adhesive material may lead to dermatitis and the method often has to be abandoned because itch is intolerable An elastic stocking overcomes some of the difficulties but the correct degree of tension is difficult to maintain and the stocking tends to stretch Unna s paste applied generously over a layer of soft gauze sets when it is cold to form an accurately moulded boot which maintains an even pressure without being rigid Unna s paste reapplied every week or ten days remains the favourite method of treatment in many clinics Finally combined ligation and injection of the varicose veins offers the possibility of prolonged control of high venous pressure Usually however it is wise to defer operation till the infection of the ulcer has been under control for several weeks because of the risk of lymph borne infection of the incision

Skin-grafting is occasionally called for in the treatment of large indolent ulcers Split skin grafts take well and give a good immediate result It cannot however be expected that the grafts will be more robust than the original skin and recurrence of the ulcer is common especially if there is any œdema Following operation therefore the patient should wear an elastic stocking by day and sleep with the legs elevated by a wedge under the mattress

Finally it must again be emphasised that the most efficient way of obtaining healing of an ulcer is by uninterrupted rest in bed for a few weeks with the leg elevated, and this tedious method should be resorted to if other methods fail

Varicose dermatitis, unlike the foregoing complications of varicose veins seldom shows improvement with radical treatment of the veins. Here conservative methods should be relied upon in the active stage and radical treatment held in reserve to be employed with the object of avoiding recurrence

The common type of dermatitis consists of a papular eruption with little or no exudate itch is intense This type responds within a few days to applications of aniline dyes An aqueous solution containing 0 5 per cent each of crystal violet and of brilliant green should be painted on to the part night and morning and allowed to dry before being covered with dry gauze *The importance of allowing the paint to dry should be made clear to the patient*

The less common type of dermatitis characterised by a copious serous exudate is difficult to treat and the patient should be referred to a specialist in skin diseases If this is not feasible the application of ichthyol-calamine liniment (B P C) is worth trial. The method of application is important The patient should be instructed to keep

the liniment in a small basin in which he can soak gauze or lint before applying it as a moist dressing the dressing requires to be renewed every six hours, or more often if the dressings tend to dry before renewal

Chronic Cellulitis—Chronic cellulitis is a fairly common sequel to repeated ulceration or attacks of dermatitis and occurs less often as a primary complication of varicose veins The skin loses its elasticity is pigmented brown, cyanosed and hairless The subcutaneous tissue is so thickened and indurated that pitting on pressure may be absent save at the proximal limit of the affected area The patient complains of discomfort but seldom of severe pain A common sequence is for the area of cellulitis to enlarge by a series of mild exacerbations till the lower half or two thirds of the leg is involved when spread ceases though the inflammation seldom shows a tendency to resolve There is no method of effecting a cure but the patient's discomfort is often lessened by wearing an elastic stocking

R A J

REFERENCES

BARCROFT H and EDHOLM O G (1946) *Lancet* 2, 513
BARCROFT H., and HAMILTON G T C. (1948). *Lancet* 2, 770
BARCROFT H., and WALKER, A. J (1949). *Lancet* 1, 1035.
BLAKEMORE, A. H., and LORD J W (1945). *Ann Surg.*, 121, 435.
BROWN J J M. (1948) "Wounds of the Extremities." *Brit J Surg.*, War Surgery Supplement No 2, 334
HEWLETT A. W., and VAN ZWALUWENBURG J G (1909). *Heart* 1, 87
LEARMONTH, J R. (1944). *Lancet* 2, 743
LEWIS, T (1936) "Vascular Disorders of the Limbs." Macmillan & Co., London.
MEDICAL RESEARCH COUNCIL (1944). War Memorandum No. 14 H.M Stationery Office.
PATERSON ROSS, J (1946) *Brit med J* 1, 1
WHITE, J C. (1948) *Surgery* 23, 834

CHAPTER VI

AFFECTIONS OF THE SKULL AND BRAIN

NEUROSURGICAL TECHNIQUE

In the last few decades improvements in technique have brought nearly every part of the brain within reach of surgery and the limits of operative intervention are fixed less by the accessibility of the lesion than by the derangement of function which is likely to result from its removal During the same period increasing knowledge of the pathology of brain tumours has led to a clearer appreciation of the appropriate methods of treatment

A surgeon should have a clear idea of the localisation of function in the brain and be able to weigh the probable effects of the operative trauma against the probable progress of the tumour if untreated thus a considerable loss of function may justifiably be incurred for the removal of a slowly growing tumour which may be completely cured whereas a similar amount of damage is not justifiable for the removal of a rapidly growing tumour which will inevitably recur

The surgery of brain tumours demands accurate localisation Clinical signs may suffice but are inadequate if the tumour involves a silent area Radiographs are valuable if they reveal focal changes in the skull (as in meningioma) or deposits of lime salts in the tumour but not otherwise Electro-encephalography may at times be helpful but usually for adequate localisation and to estimate size and spread ventriculography is needed. This is radiological demonstration of the shape of the ventricular system as outlined by a suitable contrast medium usually a gas (air or oxygen) It is safe only if the intracranial pressure is normal and the ventricular pathway unobstructed. If not it may be dangerous unless followed by operation to relieve the pressure For this reason it should not be considered as a diagnostic procedure but as a method of localising the growth preliminary to operation Occasionally direct exploration of the suspected area by cannula puncture is justified It may reveal an abscess or cyst that may then be visualised radiographically by the injection of a contrast medium *e g* thorotrast The texture of a mass may reveal its pathological nature or by suction a small piece of tissue may be obtained for biopsy but this entails a considerable danger of deep hæmorrhage To avoid these risks, cerebral angiography (p 121) may be used as although it is less accurate for localisation the vascular pattern may indicate the histological type of a tumour

Ventriculography.—The usual sites are shown in Fig 31 occipital A, temporal B, and rarely frontal C. A burr hole is made in the skull, on the side opposite the tumour or if this is not known, over the 'non-dominant' hemisphere. The dura is opened by a small incision and a special cannula is inserted clear of the cortical vessels into the lateral ventricle. The exact line and depth of the puncture are best learned by a prior study of normal ventriculographs and several attempts may be required in slightly varying directions before the ventricle is found. The fluid is then withdrawn and oxygen injected exchanging only a few cubic centimetres at a time to avoid sudden variations in intracranial pressure. When all the fluid that can be obtained has been replaced by gas the needle is withdrawn, hæmostasis assured and the wound closed. Radiographs are then taken with the head in several standard positions to demonstrate the various parts of the ventricles in turn. In the absence of free communication between the lateral ventricles both may have to be punctured.

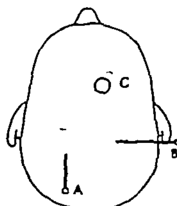


Fig. 31

Ventriculography. Surface marking of lateral ventricles, seen from above

Anæsthesia.—Since only the skin galea pericranium, and parts of the dura are sensitive many brain operations can be performed under local anæsthesia the scalp being infiltrated with ½ per cent novocaine. Addition of adrenaline to this greatly reduces scalp bleeding and for this reason the line of incision is usually infiltrated when general anæsthesia is used. This then need be deep enough only to ensure amnesia and prevent movement. Oxygenation must be full and cyanosis avoided lest troublesome hæmorrhage result. Intratracheal administration is valuable to obviate respiratory obstruction which by increasing the venous pressure would raise the intracranial tension.

Control of Hæmorrhage.—In brain surgery the nature of the tissues demands special methods of hæmostasis. Bleeding from the scalp while the incision is being made is prevented by pressing the scalp close to the cut margins firmly against the skull and later by applying hæmostats to the galea and everting it so as to compress the vessels. Bleeding from bone is best controlled by rubbing in a little Horsley's wax. Venous bleeding is reduced if the patient's head is raised. Bleeding from intracranial vessels is controlled by diathermy by the application of crushed muscle or by clips made of flat silver wire bent at an angle and applied by special forceps. These are useful for occluding dural or cerebral vessels particularly in otherwise inaccessible situations. The diathermy knife is used for incising the brain or the loop to remove small portions of brain or tumour. Small thin fragments of crushed muscle held firmly in contact for a few minutes, become adherent and are effective in arresting bleeding from small meningeal vessels or venous sinuses while the temporary application of larger fragments is useful to arrest bleeding from the brain substance. Recently a somewhat

better effect has been obtained by applying similarly, small pieces of fibrin foam or other absorbable substance which has been soaked in a solution of thrombin

Suction apparatus is essential for operations on the brain for the removal of blood and fluid so that vision is not hampered, it is also useful for removing soft tumour tissue or diseased brain

Irrigation with Ringer's solution is used for removing blood clot and to prevent drying of the exposed brain

A major intracranial operation is a lengthy procedure and the cumulative effect of even a slight blood loss may be serious Continuous intravenous infusions are regularly given and if the loss is considerable blood transfusion must be carried out

Post-operative Care—The greatest danger is hæmorrhage and this can only be prevented by meticulous hæmostasis before wound closure As soon as the blood pressure is adequate the patient should be placed in the sitting position and nursed thus for the first few days, as this prevents venous oozing and by aiding the cerebral venous drainage minimises post-operative œdema Frequent recording of the pulse respiration temperature and blood pressure and careful observation for changes in consciousness development of paralysis etc are required to detect hæmorrhage or the onset of excessive œdema The general management of such complications is as described in the section on head injuries Collections of fluid under the skin flap should be aspirated Skin sutures may be removed in five days or even for cosmetic reasons in three days Patients may usually be allowed up about a week after an uncomplicated craniotomy

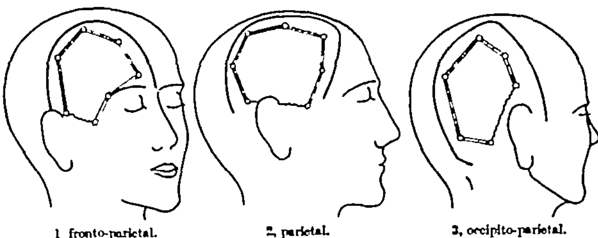
METHODS OF OPENING THE SKULL

Burr Holes—Burr holes are used for ventriculography cannula exploration and as the first step in performing osteoplastic craniotomy A short straight incision is made down to bone the skull is pierced with a Doyen's perforator (the point of which being obtuse does not penetrate the dura) and the opening enlarged to the desired size by a series of Hudson's burrs which lock in the bone opening when penetration is complete For a slightly larger but limited exposure a trephine may be used. Should the findings demand a little more exposure more bone may be removed by rongeurs

Osteoplastic Craniotomy—To expose a tumour adequately a larger area of bone must be removed, and its replacement at the end of the operation is essential The free removal of a large piece of bone is rarely practised now and the usual method is to swing the piece aside using the temporal muscle as a hinge hence the term osteoplastic Such wide exposure is advantageous when the intracranial pressure is raised for the brain then herniates less acutely and is less liable to damage while the superficial cerebral veins are less compressed at the edge of the defect and hæmorrhage is reduced.

The usual flaps are fronto parietal, parietal, and occipito-parietal (see Fig 32) The incisions except part of the frontal, fall inside the normal hairy portion of the scalp If the cosmetic result is important

an adequate though somewhat less satisfactory frontal skin flap may be fashioned by carrying the incision vertically across the scalp from



1 fronto-parietal. 2, parietal. 3, occipito-parietal.

FIG. 32

Osteoplastic craniotomy showing skin incision (red) and bone flap (blue).

just in front of one ear to just in front of the other (post mortem incision) and reflecting the flap forward over both eyes

The skin and galea are incised and reflected The bone flap is made slightly smaller so that the two incisions do not overlap and the risk of fluid leakage is reduced When practicable the bone incision should not approach the midline lest bleeding occur from the longitudinal sinus

The bone is opened by burr holes and these are joined by cuts (except across the base) made by the Gigli saw the cuts being bevelled outwards so that the flap when replaced will not fall in. The base of the bone flap is reduced in width by means of nibbling forceps till it can be broken across and the flap turned down The dura is opened by turning it as a flap base to midline as in this way the main arteries are cut across and can be controlled at once The actual opening of the dura requires care lest the cortical vessels are damaged. When the brain is exposed a tumour may be obvious on the surface or the deformation of the convolutions may give a lead to its position deeper

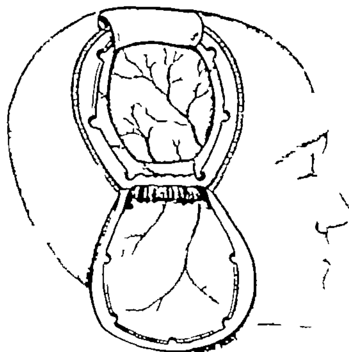


FIG 33

Osteoplastic craniotomy by the parietal approach. A bone flap hinging on the temporal muscle has been turned down. The dura mater has been reflected upwards.

in the brain Its exact location may be defined by trial punctures with a blunt exploring needle The procedures to be employed with different tumours are discussed separately

The closure varies according to the nature of the operation If the intracranial pressure has been relieved and there is no tendency to herniation the dura is completely closed the bone flap is replaced and may be fixed in position by stainless steel sutures through small drill holes The pericranium galea and skin are separately sutured by fine silk Careful closure of the last two layers should be enough to control scalp bleeding

When the intracranial pressure is raised the dura mater is not stitched in its lower part The related portion of the bone flap (the part covered by muscle) is removed by rongeur forceps and the remainder of the bone though replaced, is not fixed in position so that it may ride on the swollen brain The soft tissues must be sutured with especial care owing to the risk of fluid leakage

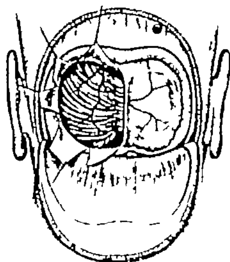


FIG. 34

Suboccipital craniectomy The nuchal flap has been turned down and the bone removed. On the left side the dura mater has been opened The small trephine opening was used to tap the lateral ventricle to relieve pressure above an tumour of the posterior fossa.

Subtemporal Decompression.—This operation is performed for the relief of increased intracranial tension mainly with the object of preventing con secutive optic atrophy It is rarely justified with irremovable malignant tumours but may be valuable in certain irremovable benign tumours and in a few other conditions The subtemporal site is chosen so that the muscle may prevent uncontrolled herniation of the brain

Access is gained either by a straight incision in the temporal region extending down to the level of the zygoma just anterior to the auricle the temporal muscle being split in the same line and retracted to either side or when wider decompression is desired by a horseshoe incision the muscle being separated from its attachment to the skull and reflected downwards The skull is opened by a burr or trephine the opening enlarged with rongeurs in all directions and the dura incised in a stellate manner When the decompression is on the side of the dominant hemisphere the dura should be left intact above the level of the Sylvian fissure to protect motor speech centres

In the closure the temporal muscle must be sutured in place with great care Where the origin of the muscle has been turned down, fine sutures of stainless steel may be used to re-attach it to the skull through small drill holes

Suboccipital Myoplastic Craniectomy—This is the most generally useful approach for access to the posterior fossa A curved incision convex upwards is made through skin and galea from the tip of one mastoid process to the tip of the other passing about 5 cm above the external occipital protuberance The flap is reflected and the occipital muscles stripped downwards off the bone till the arch of the atlas, or the axis if necessary is exposed The posterior fossa is opened and bone removed by rongeur downwards to open the posterior arch of the foramen magnum, laterally as far as possible without opening the mastoid air cells, and upward till the lateral sinus is exposed If the pressure is high a lateral ventricle should be drained through an occipital burr hole to relieve the pressure The dura is opened widely over both hemispheres and in the midline at the foramen magnum If the cerebellar tonsils are herniated through the foramen magnum the posterior arch of the atlas should also be removed and the dural incision extended downwards

When closing the dura is left open at the foramen magnum but may be loosely closed elsewhere The occipital muscles are sutured to the bone by steel wire and the pericranium sutured by interrupted silk as are the galea and skin For a well localised lesion adequate exposure may be obtained by a straight muscle splitting, midline or lateral incision with similar but more restricted bone removal

Repair of Cranial Defects.—Small defects become filled with firm fibrous tissue and repair is only done for cosmetic reasons For the repair of larger defects the only proved satisfactory material is auto genous bone A scalp flap is raised to expose the defect and a generous area around it with care not to damage the galea when freeing it from the underlying tissues to which it is usually very adherent The pericranium is reflected to expose the bone edges which are then freshened For a small defect a graft may be cut from the outer table of an adjacent area of skull and if the pericranium of the graft be left attached this may be sutured to pericranium round the edge of the defect For larger gaps half thickness grafts of rib having the appropriate curve or grafts cut from ilium may be used and wired in position Some absorption of the graft is to be expected and although the end result is mechanically sound the cosmetic result is not always good For this reason foreign material is often used as a plate by inlay or overlay and at present the evidence is that tantalum metal is best and the acrylic resins if plasticiser free are almost as good Other materials almost all give trouble sooner or later The method of inserting these plates is similar to that for bone grafts but they must be securely fixed to the skull by wires or screws etc lest they later become displaced.

HEAD INJURIES

For simplicity in description these conditions are here classified anatomically but it must be remembered that two or more are often associated *e.g* a patient with a scalp wound may also have cerebral contusion or a patient with a compound fracture of the skull may have

laceration of the brain beneath the fracture and contusion with resultant œdema in other parts of the brain Each lesion requires its own line of treatment and should these not be compatible the most serious lesion has therapeutic precedence The very severely injured usually die within twenty four hours and no known treatment is of any use in them In the others apart from the treatment of shock and extra dural hæmorrhage there is no great therapeutic urgency

First Aid

Treatment of shock whether from head or other injuries is the first essential and the victim should be moved only enough to facilitate this Unconsciousness may mask some of the features of shock but pulse and blood pressure observations obviate any error A scalp wound should be covered with a dry sterile or moist flavine dressing and bandaged firmly to prevent further contamination hæmorrhage is rarely troublesome but brisk arterial bleeding can be controlled by a few sutures passing through the whole thickness of the scalp to approximate the skin edges The extra handling required for X ray examination is not justifiable at this stage unless extradural hæmorrhage is suspected After shock has passed off these cases usually stand transportation quite well

Scalp Wounds

For adequate treatment anæsthesia is required Local anæsthesia is usually sufficient and should be used if there is any associated cerebral damage

The scalp is shaved for a generous area round the wound or completely in extensive wounds When local anæsthesia is used if a ring of skin round the wound is first shaved and anæsthetised the rest of the shaving and the cleansing of the wound can be done painlessly Contused wound edges and all contaminated tissue are excised down to and including the pericranium and if there is dirt ground into the surface of the skull it may be necessary to remove a layer of the outer table to get rid of the contamination Where a large area of scalp is avulsed as much as possible should be saved, though not at the expense of adequate excision The blood supply is so good that a surprisingly small base may be adequate to maintain nutrition The galea is sutured as well as the skin to get hæmostasis In small wounds this may be done as one layer otherwise the galea and skin are sutured separately with interrupted fine silk The skin sutures may be removed in four days If a better cosmetic result is required subcuticular sutures may be used In large wounds with much undermining a small rubber drain for twelve hours allows escape of oozing blood and serum from under the flap When there is some loss of scalp closure may be aided by sliding flaps but if this fails early grafting should be done

Simple Fractures of the Vault

Linear fractures require no special treatment

Depressed fractures do not require urgent operation unless complications develop When the patient s condition has improved from the initial shock, radiological investigation (stereoscopic views) to determine the full extent of the bone damage and thorough neurological examination to assess the amount of underlying brain damage are required While a depressed fracture in itself does not necessarily cause important sequelæ an associated tear of the dura will produce a meningo-cerebral cicatrix which may later cause headache or predispose to epilepsy Hence unless by X ray it can be shown that there is so little abnormality of the inner table that the dura must be intact operative interference should be advised In the frontal region operation is also indicated for cosmetic reasons

The depressed area is exposed by reflecting a large flap of the overlying scalp as in an osteoplastic craniotomy The pericranium also is dissected off the depressed fragments as a flap A burr hole is made just to one side of the depression and working from this the depressed fragments are loosened removed and stored in saline If the dura is torn it is opened more widely to inspect the underlying brain If the dura is intact it should be opened if blood clot is seen under it or if neurological examination indicates damage to the underlying brain

All blood clot and damaged cerebral tissue are then removed by gentle irrigation and suction Such a procedure may seem radical but cerebral tissue has no power of regeneration and the amount of scarring in a brain wound is directly dependent on the amount of dead tissue that has to be absorbed When no special apparatus is available suction can be carried out satisfactorily by a rubber ball syringe attached to a rubber catheter for such a syringe is not strong enough to remove normal brain tissue but can deal adequately with blood clot and damaged tissue

After complete hæmostasis the dura is closed The bone fragments are replaced to fill the skull defect and to encourage bony union which is rare except in children the large fragments may be fixed to one another and to the intact skull by fine stainless steel sutures passed through drill holes The pericranium is then sutured back over the fragments and the scalp is closed with separate sutures for galea and skin.

The pond-shaped depression in infants is usually easily raised by inserting a stout elevator through a burr hole just to the side of the depression between the bone and the dura and levering out the fragment When this fails a horseshoe skin flap is raised and the depressed area cut out reversed and preferably wired in place

Compound Fractures of the Vault

While early adequate operation with closure is the best safeguard against septic complications the local application and systemic administration of penicillin and sulphonamides now permit a longer

waiting period to improve the patient's general condition for operation and to permit transport if necessary to a centre where facilities may be better

Local anæsthesia is advisable A wide area preferably the whole scalp is prepared so that the wound can be enlarged freely in any direction The edges of the scalp wound are excised in the usual manner and the wound may be enlarged to expose the extent of the fracture though it is better to turn a wide scalp flap As a general principle all potentially infected bone is removed regardless of the defect left With a *linear fracture* a small burr hole is made just to one side of it through this the dura is freed from the skull along the fracture and the bone edges where potentially infected removed by rongeurs Such an excision may reveal an unsuspected dural tear (see below)

Comminuted and depressed compound fractures require a more extensive procedure All contaminated bone, all bone fragments separated from their pericranium (whether contaminated or not) and all contaminated pericranium are removed Bone fragments are removed cautiously to avoid injuring the dura and brain A fragment lying over a venous sinus is often best left alone lest the sinus be opened and a hæmorrhage started which in the absence of special facilities may prove uncontrollable

When the dura is torn the edges are excised contaminated areas removed and the opening enlarged if necessary to view the extent of the underlying brain damage

Blood clot and contaminated or devitalised brain must be removed by irrigation and suction as described above Search must be made for buried spicules of bone or other foreign bodies which should preferably have already been demonstrated and located by X ray examination If such a foreign body is accessible it should be removed, and any infective material carried on ahead of it evacuated by irrigation and suction A deeply placed missile should be left unsought lest attempts at its removal inflict further damage

The dura mater is then closed as completely as possible any defect filled by a free fascia graft and the scalp sutured A drain (through a separate skin wound) may be inserted down to but not through the dura If the scalp cannot be closed without tension a sliding flap should be fashioned to cover the area of the bone defect A gap in the scalp over intact bone can be covered later by skin grafts During closure the layers may with advantage be dusted with penicillin and sulphonamide (other than sulphathiazole as this may cause convulsions) powder and penicillin and sulphonamides given systemically for several days

Leakage of cerebrospinal fluid after fracture is dangerous owing to the risk of infection gaining access to the subarachnoid space After compound fractures of the vault the risk of leakage is minimised by careful suture of the dura galea and skin while if leakage occurs it can generally be arrested if the intracranial tension is reduced by lumbar drainage

After a fracture involving the nasal passages or frontal sinuses leakage of cerebrospinal fluid from the nose is a serious complication

and is rarely cured except by operation The conscious patient is warned not to blow his nose lest he force infected material into the cranium and the semiconscious patient must be prevented from any such attempt The risk of infection passing inwards is reduced by keeping the head low so as to ensure a constant outward flow of cerebrospinal fluid As soon as the patient s general condition permits and the site of the fracture has been determined by X ray examination the dural wound is exposed through a frontal osteoplastic flap bilateral if necessary It is repaired by suture if possible and reinforced by a fascial graft fixed extra or intra-durally

After fracture of the middle fossa leakage from the ear is not uncommon Spontaneous arrest of the leakage is usual and no operation is required Strict surgical cleanliness of the external meatus is maintained and the head is kept low with the ear down to prevent collection of fluid in the meatus and backflow of infection into the cranium Sulphonamides should be given by mouth and sodium penicillin given by lumbar puncture at least 10 000 units a day and once an adequate bacteriostatic level is reached in the cerebrospinal fluid the head may be elevated slowly till the leakage lessens and stops When the leakage is considerable, especially in children it may tend to produce a chloride deficiency

Concussion and Cerebral Contusion

In patients rendered unconscious through head injury the condition varies from a mild transitory disturbance without gross pathological changes (concussion) to all grades of contusion and laceration of the brain In these latter injuries the clinical effects are mainly caused by secondary congestion and œdema of the brain and not by destruction of the brain tissue *per se.* Their severity varies greatly some are immediately or rapidly fatal some progress to complete recovery in the course of a few days or weeks others progress slowly and cause prolonged disability

Often when the patient is first seen the severity of the condition can readily be assessed thus rapid complete recovery of consciousness will denote a mild concussion while at the other extreme deep coma stertor a rapid pulse-rate and pupillary changes will indicate severe damage In others however the severity can be assessed only by continued observation of the progress and the response to treatment Fortunately whatever the precise pathological lesion, the general management of the case is the same

In mild concussion little treatment is needed but it is wise to keep the patient under close observation for forty-eight hours in case complications develop In more severe concussion the patient should be kept completely at rest without physical or mental exertion of any kind for a longer period the length of treatment being varied according to the duration of the unconsciousness or if this is not known according to the length of the period of amnesia Skull X rays should be taken and if a fracture is found the possibility of extradural hæmorrhage must be remembered and in any case a longer period of rest

advised Patients especially those past middle life should be observed occasionally during the next few months for signs of subdural hæmatoma

In more severe injuries with evidence of cerebral congestion and œdema careful and prolonged treatment is necessary During the period of unconsciousness careful nursing is required to ensure adequate intake of fluids and nutriment to maintain the body temperature to regulate the bowels and to prevent pressure sores Later special measures are required to prevent or control restlessness If there is evidence of increased intracranial tension the appropriate treatment must be instituted Throughout the course of treatment the pulse-rate temperature and general state of the patient should be recorded at frequent intervals and a careful watch kept for any sudden change in the condition and for the development of paralysis

Fluids and Nutrition.—A careful note should be kept of the fluid balance and an adequate intake of fluids and easily digested food should be ensured if necessary by stomach tube or even by intravenous infusion

Temperature—After injuries to the brain the control of body temperature may be disorganised In such circumstances overheating is as dangerous as underheating The *rectal* temperature should be noted two-hourly and the body heat regulated either by judicious application of blankets and bottles or by removing covers and, in extreme cases by cold sponging after vigorous rubbing of the skin to induce capillary dilatation

Restlessness.—The patient should be nursed in a quiet darkened room his eyes shaded from any light Restraint should be applied only if the patient is in danger of injuring himself or getting out of bed, as forcible restriction of movement tends to increase struggling When control must be exercised restraining sheets are used (strong canvas sheets strapped to the sides of the bed) and the hands and feet may require to be held by straps but even then the fixation should not be rigid but allow a certain range of movement

Sedative Drugs.—These must be used with discretion as they may mask the development of signs of complications In mild cases aspirin and codeine relieve headache In more severe cases chloral and bromide are usually satisfactory Paraldehyde is useful at night up to by mouth 4 drams or by rectum 8 drams Luminal may be given by mouth or sodium luminal intravenously Morphine is rarely necessary and should be avoided particularly if there is any depression of the respiratory centres

Bladder and Bowel.—Retention of urine is common and may be a cause of restlessness in a semiconscious patient It is best treated by repeated catheterisation or if long continued by the use of an indwelling catheter In the latter event frequent lavage of the bladder is necessary to prevent the development of cystitis

The bowels are best controlled by the regular use of enemas If hypertonic rectal injections are used to effect dehydration (see below) no other treatment is required for the bowels

Control of Increased Intracranial Tension.—Increased intracranial

tension is a common feature in intracranial injuries and is usually more marked in severe lesions Confirmation may be obtained by lumbar puncture but this should not be done if an extradural hæmorrhage is suspected as it may fatally aggravate a developing pressure cone' The patient should be placed with the spine horizontal and the pressure of fluid at the lumbar needle estimated by manometer Care must be taken that the patient is relaxed breathing freely and with no constriction of the veins at the neck otherwise too high a reading will be obtained In assessing this test it must be remembered that while a high reading is significant a low reading may be due to general dehydration in a patient who would otherwise have shown a raised intracranial tension Increased intracranial tension interferes with the venous drainage of the brain and so perpetuates cerebral œdema hence its reduction is desirable Elevating the patient's head by aiding venous drainage is advantageous and further reduction may be obtained by dehydration therapy or by lumbar drainage

Dehydration Therapy —In mild cases this may be achieved by the administration of concentrated solutions of magnesium sulphate or sodium sulphate by the mouth in doses insufficient to cause severe purging (½ oz of saturated solution four hourly for two to three days) In more severe cases hypertonic rectal injections may be given twice daily 2 to 4 oz of a saturated solution of magnesium sulphate being instilled into the rectum and retained there as long as possible In still more severe cases 100 c c of a 50 per cent aqueous solution of sucrose or glucose (the former being better but the latter more easily obtained) may be given slowly intravenously and repeated three or four times at intervals of four hours by osmosis it withdraws fluid from the œdematous brain, and the fluid thus withdrawn is rapidly excreted by diuresis Whichever of these methods is adopted care must be taken to guard against too severe general dehydration and to make up the fluid intake as soon as the state of the intracranial pressure permits They should therefore not be used for more than one or two days and if the intracranial pressure is still high lumbar drainage should be instituted as this does not upset the general fluid balance of the body

Lumbar Drainage —Lumbar puncture is performed running off fluid till the pressure falls to normal (about 120 mm of cerebrospinal fluid) When high initially the pressure rises rapidly again and frequent punctures are needed With moderate increase of pressure puncture once a day is enough

After-treatment.—Apart from penetrating injuries with gross cerebral destruction well defined neurological signs are rarely found after head injuries Most patients have some residual headache which clears up spontaneously but a minority complain of more severe symptoms the commonest of which are headache dizziness (a feeling of faintness rather than true vertigo usually) transitory visual blackouts undue physical and mental fatigue inability to concentrate intolerance of noise and personality changes While the severity of these symptoms is often directly related to the degree of injury at other times they seem to correlate more with the pre accident mental

status of the patient and to the psychological stresses of convalescence To minimise organic damage bed rest is advisable till cerebral reaction has settled and intracranial pressure is stabilised at normal There after a series of graduated exercises ranging from bed to heavy ' will minimise the more physical of these symptoms For the treat ment or better prevention of the others the help of psychiatrist and social worker is advisable to elucidate and smooth the psychological difficulties of the patient

After concussion, except the most transient the patient should be advised to take a week s holiday while following severer types of head injury after treatment as already outlined a period of con valescence is required During this the patient should have regular hours ample sleep and at first one or two rest periods during the day when he lies down but increasing activity is encouraged The duration of convalescence depends on the severity of the injury the rate of recovery nature of the patient s work and not least his psychological outlook After mild contusion two months is usually ample but after a severe injury up to six months may be needed During this period alcohol is contraindicated and the patient should lead as far as possible an outdoor life Some patients may be helped by a period of retraining before resuming work, and after severe injuries less exacting employment may have to be found for the patient

Many patients tend to be impulsive and intractable and are apt to discontinue treatment too early while others dreading the con sequences of their injury anticipate sequelæ To enforce greater activities against their own desires is rarely successful and may pre dispose to subjective symptoms whose genuineness is difficult to assess on the other hand too conservative an attitude is equally harmful Good judgment tactful control and management are therefore essential

The occurrence of sequelæ is minimised by adequate treatment but is not always prevented When they are mild, an intelligent patient may be able to make the necessary adjustments to accept them as part of his normal life That residual symptoms may be due to sub dural hæmatoma should be borne in mind, and diagnostic exploration may be advisable When continued severe localised headache is the predominant symptom injection of air into the subarachnoid space—a therapeutic encephalogram —may give relief

Of the true organic sequelæ anosmia is not uncommon and cannot be relieved palsies are treated in accordance with orthopædic prin ciples and dysphasias may respond well to re-educative measures Epilepsy should be treated by anticonvulsants and if there are adequate indications by operation (*v infra*)

EXTRADURAL HÆMORRHAGE

In traumatic cases this is almost always associated with a fracture of the skull the bleeding being from a tear of a meningeal artery diploic vessel venous sinus or pacchionian granulation. A hæmorrhage large enough to produce symptoms results most frequently from a tear of the middle meningeal artery or one of its branches and is most likely

when the vessel lies in a deep groove in the skull The tear is commonly situated near the pterion or in the middle fossa

When an extradural hæmorrhage is suspected a radiograph of the skull should be taken The absence of a fracture practically excludes extradural hæmorrhage a unilateral fracture gives the side of a hæmorrhage and a fracture crossing an arterial groove indicates the probable site of the tear In bilateral fractures the side on which the hæmorrhage is situated is determined on clinical grounds and in the unconscious patient this may be a matter of some difficulty The pupils are usually unequal, that on the side of the hæmorrhage at first being smaller, later becoming dilated and fixed Usually paralysis is seen on the side of the body opposite the hæmorrhage due to direct pressure on the cortex However, in the presence of a massive hæmorrhage the dislocation of the brain may be so great that the contralateral motor pathways in the crus cerebri are compressed against the edge of the tentorium with resulting paralysis on the same side of the body as the hæmorrhage This homolateral paralysis is usually more spastic than the contralateral so if the other signs are doubtful one should explore the more spastic side first



FIG. 35

Extradural hæmorrhage. The middle meningeal artery is shown in red. The blue line indicates a common site for fracture.

While it may be possible to control the original bleeding point through a small skull opening for the efficient removal of clot and the control of further bleeding from the dura where it has been stripped from the skull by the clot it is best to turn down a large osteoplastic flap after confirming the presence of clot by an exploratory burr hole The blood clot is evacuated by irrigation and suction and the torn vessel identified and controlled by diathermy silver clip or by under running it with a fine suture It may be easier to control the middle meningeal artery by plugging the foramen spinosum with a small piece of cotton wool or a spicule of wood. Secondary bleeding points on the dura must be located and controlled and oozing is greatly reduced if the dura is sutured to the pericranium at intervals round the edge of the bone opening With good hæmostasis drainage is unnecessary

When the middle meningeal artery is intact the *origin of the* hæmorrhage from one of the other sources mentioned should be sought by removing bone along the fracture line with rongeurs and the bleeding *controlled* in the appropriate manner *e.g* by application of crushed muscle to a tear in the wall of a sinus

SUBDURAL HÆMATOMA AND HYDROMA

The former may follow quite trivial injuries and symptoms may be delayed for several months Probably due to bleeding from the veins

favourably situated cannot be completely removed though its effects may be delayed or mitigated either by external decompression (subtemporal or suboccipital) or better by internal decompression in which part of the tumour and an adjacent 'silent area' of the brain are removed to give space for further growth, which in some cases may be considerably retarded by adequate X ray therapy

A glioblastoma (gliosarcoma) finally grows so rapidly and is so little responsive to X ray therapy that treatment avails but little Even after the most critical assessment of a case one may be uncertain as to the true pathological nature of a brain tumour For example, a cystic astrocytoma (gliomatous cyst) in which the tumour tissue consists of a mural nodule which can easily be excised in its entirety with permanent cure may be found in the cerebellum of a child and may be clinically very like the more frequent medulloblastoma This tumour usually arises from the roof of the fourth ventricle grows rapidly and tends to seed down the spinal canal It does respond well to X ray therapy but almost invariably recurs When there is reasonable doubt therefore exploration is justified but since secondary carcinoma of the brain especially from a bronchial primary is so common a brain tumour should not be explored without at least a preliminary chest X ray

Meningioma —Tumours of this class are of benign character, for though they invade the dura locally and even the overlying skull they do not invade the brain but merely displace it The treatment if technically feasible is to remove the tumour with the involved dura and bone Even partial removal may relieve symptoms for a period of years, and further operation then may give further relief

When the tumour is on the convexity of the cerebral hemisphere approach is by the appropriate osteoplastic flap, the dura is incised round the tumour outside the invaded area and the centre of the tumour removed gradually by diathermy till the shell of tumour left can be pulled away without damaging the brain in which it is embedded The area of invaded skull is removed the dural defect repaired by a fascial graft and the wound closed Since the tumour and all the overlying tissues may be very vascular there is apt to be a considerable loss of blood A two stage operation may occasionally be advisable and blood transfusion is commonly required.

When the tumour arises from the base of the skull it may be necessary to resect a portion of healthy brain for example the frontal lobe or the cerebellum to gain access In such cases it is generally not possible to remove the invaded bone but the growth may be destroyed partially or completely by heavy application of diathermy

Neurinoma (Neurofibroma) —This benign tumour usually arises in the acoustic nerve and complete removal can frequently be carried out usually with sacrifice of the facial as well as the involved acoustic nerve There is considerable risk of damage to the branches of the basilar artery which may be closely applied to the tumour capsule Using a unilateral sub-occipital approach going above the level of the lateral sinus and retracting or partially resecting the lobe of the

cerebellum the tumour is exposed its capsule incised and the contents scooped out The capsule may then be carefully dissected out freeing it cautiously from the adherent nerves and vessels However when the tumour is very large or the patient a poor operative risk this step may not be feasible and then the capsule is left *in situ* recurrence is inevitable but relief for five or more years is obtained and a further operation may then be done

Pituitary Tumours.—Here the main indication for operation is to prevent or retard loss of sight Surgical treatment has little effect on the endocrine manifestations of the tumour though occasionally hypopituitary symptoms are relieved after operation presumably by restoration of function in a portion of the gland previously compressed. If the visual loss is slight and not rapidly progressive deep X ray therapy may be tried though it must be used cautiously lest by producing hæmorrhage it causes sudden increase in the size of the tumour and further damage to the visual pathways With more rapid loss or where radiotherapy has failed to arrest progress operation is indicated to relieve pressure on the visual pathways To accomplish this the part of the tumour projecting upwards from the sella must be removed The frontal route is preferable to the earlier transphenoidal route with its risk of meningitis its limited visual control and the consequent danger of troublesome hæmorrhage A small frontal osteoplastic flap is raised on the side of the more defective vision, the dura opened below the flap or elevated back to the lesser wing of the sphenoid and there incised the frontal lobe elevated and the chiasmal region thus exposed The tumour is seen between the optic nerves or related to the chiasma the capsule is incised and the contents removed by a small spoon and suction The capsule is then separated from the surrounding structures if this can be done without damaging them and excised

Pinealoma—Operative removal of this tumour may be attempted although difficult on account of its situation and size Access may be gained by approaching between the parietal lobe and the falx cerebri (splitting the splenium of the corpus callosum) by going through a dilated lateral ventricle or by resecting part of an occipital lobe These methods have a high mortality cause considerable brain damage and recurrence is usual Since the main symptoms are due to obstruction of the aqueduct of Sylvius relief often for many years may be obtained at much less risk by ventriculo-cisternostomy (see below) followed by X radiation of the tumour

Tumour of Rathke's Pouch (*Cranio-pharyngioma Supra-sellar Cyst*)—Access to this tumour is similar to that for pituitary growths Complete removal is difficult and hazardous but incomplete removal gives much relief and is worth attempting If as is commonly the case the lesion is entirely cystic temporary relief may be obtained by simple puncture

Paraphyseal Cyst (*Colloidal Cyst of the Third Ventricle*)—This is a benign tumour which blocks the foramina of Monro producing dilatation of both lateral ventricles It can be diagnosed with certainty only by ventriculography and is therefore liable to be missed It can be

removed by operation access being gained by incising the frontal cortex opening into the anterior horn of the lateral ventricle and if necessary enlarging the foramen of Monro

INTRACRANIAL INFECTION

Epidural Abscess.—This is usually associated with an area of bone infection from a mastoiditis frontal sinusitis or infected fracture and is treated by removing all diseased bone and enough healthy bone to give adequate drainage

Meningitis.—Infection of the leptomeninges may follow a penetrating wound or compound fracture of the skull may occur as a complication of mastoiditis and suppuration in the paranasal sinuses may result from leakage from a brain abscess or may arise from a blood borne infection

A primary local focus of infection should be dealt with as soon as the patient's condition permits In the absence of papillœdema lumbar puncture is performed to determine the nature of the infecting organism so that appropriate chemotherapy may be established Additionally when the causal organism is sensitive to penicillin (most are) 10 000 units or more of the purest available sodium salt should be given by lumbar puncture daily If rapid response is not obtained or if there is a relapse a similar dose should be given into a lateral ventricle (approach as for ventriculography) If this fails pneumographic studies are advisable as a leaking abscess etc may thus be located In the presence of papillœdema an abscess should be suspected, and ventriculography performed to locate it so that it may be treated Intraventricular therapy is then used till the papillœdema subsides when lumbar puncture should be safe

Basal adhesions are liable to form especially in cases inadequately treated initially and a chronic hydrocephalus results When the active infection is controlled these may be amenable to treatment (v hydrocephalus)

Sub-dural abscess may occur in association with epidural abscess or as a complication of leptomeningitis Multiple burr holes or raising an osteoplastic flap and incision of the dura allow free drainage The causal organisms are frequently penicillin sensitive and then fine catheters are inserted through the burr holes to the limits of the infected space and penicillin instilled through these at least twelve hourly Penicillin is also given systemically

Cerebral Abscess—A cerebral abscess may be due to local spread of infection from the mastoid air cells the paranasal sinuses or a compound fracture of the skull or to blood borne infection from a thoracic suppuration such as bronchiectasis or may be a complication of *meningitis*

The infection often starts as a non-circumscribed encephalitis and may prove rapidly fatal with little or no pus formation If the infection is less virulent the area tends to become walled off and an abscess forms As the infection becomes subacute the wall of the abscess becomes progressively thicker and more fibrous In a chronic abscess

EPILEPSY

Surgical treatment is indicated only in those cases of epilepsy where the condition is attributable to scarring of the brain or meninges consequent upon injury hæmorrhage or infection and a focal origin in the cortex is shown by electro-encephalography It is contraindicated in cases with marked mental degeneration or with a family history of epilepsy and where removal of the scarred area would leave dysphasia or other severe disability The procedure is to raise an osteoplastic flap and to excise the scar along with a margin of healthy brain and the related meninges The operation can be performed under local anæsthesia and the focus of irritation may be defined with precision by stimulating the cortex with weak faradic current which should produce a typical attack

HYDROCEPHALUS

Hydrocephalus results from interference with the normal flow or absorption of the cerebrospinal fluid It may be treated by removing or short-circuiting the obstructing agent (usually adhesions) or by destroying the source of the fluid in the choroid plexuses

If the obstruction is in the aqueduct of Sylvius ventriculo cister nostomy is indicated Either the third ventricle at the lamina terminalis may be opened into the chiasmatic cistern (third ventricul ostomy) or one lateral ventricle may be drained to the cisterna magna by a buried catheter If the adhesions are situated over the roof of the fourth ventricle they may be displayed by sub-occipital exposure and broken down If the adhesions are at the base of the brain they may be short-circuited by third ventriculostomy

If there is a congenital failure in the development of the subarachnoid absorptive areas a ventriculoscope may be introduced into the lateral ventricle and the choroid plexus destroyed by fulguration The opera tion to be successful must be done early in infancy to prevent mental deterioration The risk is considerable for the child is usually weakly and intercurrent infection is common.

LESIONS OF THE CEREBRAL BLOOD VESSELS

Cerebral Angiography is extensively used for the accurate localisation of intracranial blood vessel abnormalities aneurysms and some tumours The percutaneous method is most frequently used the common carotid on the side to be investigated being punctured by a needle of bore large enough to permit rapid injection of the contrast medium (10 cc in 3 to 4 secs) Clotting in the needle is prevented by the slow injection of normal saline between injections of the contrast medium It is thus possible to get several sets of films lateral (stereo if desired) and antero posterior being the usual A quick film changing device allowing exposures about every two seconds permits the arterial and venous circulation to be demonstrated with each injection the first exposure

being made just at the end of the injection The usual contrast medium is diodone 35 per cent (occasionally 50 per cent) but its use should be preceded by sensitivity tests Thorotrast because of its retention in the body and its radioactivity is a less desirable alternative

When the percutaneous method fails or routinely if thorotrast is being used the common carotid is exposed by operation either in region of the bifurcation in the neck or between the heads of the sternomastoid muscle These procedures may be done with local or light general anaesthesia

Angiomatous Malformations —With the smaller of these it may be



FIG. 36

Arteriogram showing angioma on medial side of right hemisphere with large feeding artery from dilated anterior cerebral artery (35 per cent. diodone).

possible to ligate the feeding arteries their location having been revealed by arteriography and excise the lesion (Fig 36) In the more extensive however this may be a hazardous affair or technically not feasible As an alternative radiotherapy may be used but is much less satisfactory

Aneurysms.—Spontaneous subarachnoid haemorrhage is usually due to an aneurysm in the region of the circle of Willis These may be multiple but in view of the grave prognosis arteriography should be done and if this reveals a single aneurysm arising below the division of the carotid ligation of the internal carotid in the neck often suffices

to cure by allowing thrombosis to occur in the aneurysmal sac (Fig 37) When the sac arises from one of the branches of the carotid if pedunculated the stalk may be clipped off or where favourably situated *e g* from the anterior communicating artery the vessel on either side of it may be occluded by silver clips

Carotid cavernous arteriovenous aneurysm is best treated by ligation of the internal carotid artery in the neck This usually cures but if symptoms recur the intracranial portion of the artery may be exposed through a pituitary approach and occluded as it emerges from



FIG 37

Arteriogram showing aneurysm of internal carotid artery arising near bifurcation (35 per cent. diodone).

the cavernous sinus thus leaving only the ophthalmic artery connected to the aneurysm

Before ligating the internal carotid artery in the neck the adequacy of the anastomotic circulation should be tested by digital compression of the common carotid artery which should produce no symptoms when maintained for thirty minutes If inadequate it may be improved by frequent repeated compression of the common carotid for gradually increasing periods The common carotid artery only may be ligated as a first stage the internal being tied off a few weeks later After ligation of the internal carotid the patient should be kept flat for

about two weeks and only gradually raised to a sitting posture thereafter By such methods the risk of a hemiparesis is minimised

LESIONS OF THE CRANIAL NERVES

Trigeminal Nerve—Trigeminal pain in its milder forms sometimes responds to simple methods of treatment such as the removal of infected teeth or drainage of infected sinuses but in the more severe form tic douloureux or *chronic paroxysmal trigeminal neuralgia* these measures have no effect (though spontaneous remissions may give rise

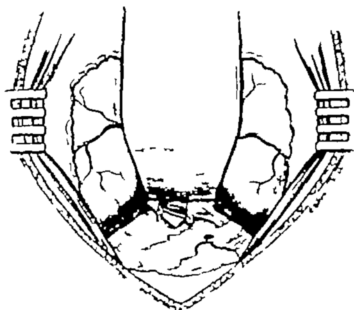


Fig 28

Trigeminal neuralgia; division of sensory root. The dura mater is displaced upwards by the retractor The foramen spinosum is seen in the floor of the middle fossa, with the middle meningeal artery emerging from it. Part of the sensory root has been divided, revealing the motor root on its deep aspect.

to false hopes) and the only satisfactory treatment is to destroy the pain-carrying fibres of the nerve

This may be done by injection of alcohol or by operative division. Injection of alcohol may be practised for pain involving the second and third divisions of the nerve, and if the nerve is accurately injected relief may be obtained for a few months or as long as two years Alcohol injection of the semilunar (Gasserian) ganglion is difficult to control is not without serious risk and as all divisions are likely to be destroyed the risk of keratitis is greater than after operation It should be reserved for patients unfit for operation and with proper precautions these are few

The treatment of choice is operative section of the root of the fifth nerve between the ganglion and the pons (rhizotomy) The operation

may be performed under local anæsthesia with basal premedication The patient is placed in the head up position to reduce venous bleeding The skull is opened as for a small subtemporal decompression, the dura raised from the floor of the middle fossa, the middle meningeal artery controlled by plugging the foramen spinosum and divided, and the nerve root exposed in the cavo of Meckel Any desired amount of the sensory root may then be sectioned and the motor root spared The anatomical relationship of the fibres in the root does not correspond exactly to the ultimate divisions of the nerve, but there is enough segregation immediately behind the ganglion to make a differential section practicable If the first division is not involved its fibres may be spared thus saving corneal sensation and avoiding the risk of keratitis When the first division is involved section will render the cornea anæsthetic, and the eye must be protected against drying and the entry of grit the simplest and least obvious method being a side shield attached to ordinary spectacles The root may be sectioned in the posterior fossa, but this has no real advantage over the temporal approach

With all these methods all forms of sensation are lost in the area denervated The resulting anæsthesia is a trivial disability and is usually gladly accepted by the patient as a small price to pay for the relief obtained Theoretically it is not ideal however and for this reason recently operative section of the fibres of the descending root of the trigeminal nerve where they lie in the medulla has been practised This results in analgesia of the whole trigeminal area without loss of tactile sensation or motor power The operation is more severe than a rhizotomy, and it is doubtful if the sparing of sensation is worth the added risk except in a few selected cases, where all three divisions are involved.

Facial Nerve.—*Facial palsy* may follow damage to the nerve in the brain stem, in its intracranial course in its bony canal, in the neck, or in the face Intracranial damage may be by tumour or hæmorrhage and if there is no spontaneous recovery the facial disfigurement may be improved by the plastic procedures described below

In its bony canal the nerve may be paralysed by spread of infection from mastoiditis or by accidental section in the course of a radical mastoidectomy The most satisfactory treatment is to open up the canal widely once the infection is under control to decompress the nerve in the first case or unite the nerve ends by suture or through an autogenous nerve graft in the second (as a graft a piece of the intermediate femoral cutaneous nerve is excellent) In the neck or face the nerve may be divided by accidental wounds or in the course of an operation, for example removal of parotid tumour Exposure and suture of the cut ends may be attempted but since the nerve divides shortly after it leaves the stylomastoid foramen, repair is technically difficult and unsatisfactory and in these cases a plastic operation is usually best

In *Bell's paralysis* the nerve is compressed in its bony canal by inflammatory swelling of the perineural tissues Usually there is spontaneous recovery and the only treatment required is to prevent overstretching of the paralysed muscles and to protect the eye If

recovery does not occur *operative decompression of the nerve in* canal should be carried out Opinions differ as to the best time : this but the general view is not to wait more than two months l permanent paralysis result Occasionally after a good recovery sp modic contracture of the facial muscles may occur, and in sev cases the nerve may have to be sacrificed and facial symmetry restor by plastic operation

Conservative Treatment—Stretching of the paralysed muscles prevented most effectively by the application of strips of adhes plaster to pull back the angle of the mouth adjusting the directi and pull to the needs of the case A small hook in the angle of t mouth attached to a ring round the ear is much less conspicuous a may be sufficient in milder cases Nutrition of the facial muscle helped by massage and galvanic stimulation Faradic excitability the muscles may not be completely lost or may reappear early and these cases a good prognosis may be made When faradic excitabili returns the patient should attempt voluntary movements of the fa before a mirror and persist with these exercises till recovery is complet which may take six months or more Closure of the eye may be aid by narrowing the palpebral fissure with adhesive strapping just later to the external canthus If this is insufficient to protect the low part of the cornea a shield should be worn

Neurolysis—The facial canal is exposed by a wide incision as f a radical mastoidectomy clearing out all air cells and removing t tip of the mastoid process Care is required not to damage the later semicircular canal and the contents of the middle ear The can should be fully opened up

Plastic Operation—Strips of fascia lata are inserted subcutaneous from the angle of the mouth and from the eyelids to the masseter an temporal fasciæ the tension being adjusted so as to overcorre slightly the deformity at rest The palpebral fissure may be narrowe permanently by a partial tarsorrhaphy to ensure that the cornea fully covered when closure of the eye is attempted.

Acoustic Nerve—Paroxysmal vertigo of vestibular origin, associate with unilateral deafness and vertigo following a fracture through petrous bone may require operative treatment if simpler methods fai The operation consists in dividing the vestibular portion of the nerve which is approached through a small unilateral suboccipital craniectomy If hearing is reduced below a useful level all the nerve may be sectioned otherwise some auditory fibres are spared by dividing only the anterio two-thirds of the nerve The underlying facial nerve and interna auditory artery must be identified and spared

Glossopharyngeal Nerve—Section of this nerve in the posterio fossa, by an approach similar to that used for section of the acousti nerve is indicated in cases of paroxysmal glossopharyngeal neuralgia. By this means the nerve is sectioned proximal to its ganglion with permanent relief

J S R.

CHAPTER VII

AFFECTIONS OF THE SPINE AND SPINAL CORD

SCOLIOSIS

THE investigation and treatment of scoliosis is a complex problem about which there are many and divergent opinions. In general, it may be said that the treatment and prognosis depends on the early recognition of the deformity in relation to the clinical type and etiological classification.

Importance of Early Recognition.—Scoliosis is symptomless in all but the late stages in adult life. The first complaint is of the deformity. This is rarely noticed by the parents until it has reached an advanced stage, and it is the common experience that attention is first directed towards it by a dressmaker or gym teacher who observes the prominent hip or high shoulder. It is therefore most important that examination of the spine form part of the routine physical examination or medical inspection of every child of school age.

There are two distinct clinical types :—

Functional, Postural, or Mobile Scoliosis.—This type of spinal curvature is the result of temporary postural influences and is seen in children in whom there is frequently other evidence of muscular weakness such as round shoulders, protuberant abdomen and abducted feet, or may be the functional response to non-spinal conditions such as a short leg or hip ankylosed in adduction or abduction and producing a pelvic tilt.

In the former circumstance the lateral curvature is usually a temporary deformity and disappears in the course of a few years either with or without treatment. A small percentage of untreated cases progress, develop morphological changes, and thus undergo transition into the structural type.

The treatment includes general and local forms of therapy. All factors deleterious to general welfare must be eradicated, and thus it may be necessary to investigate the child's mode of living and advise the parents about diet, adequate sleep, and fresh air, and avoidance of mental and physical fatigue. Postural habits which might be caused by clothing, school desks, defective eyesight or hearing, the habitual standing on one leg or the carrying of a heavy schoolbag on one side must be carefully considered and their importance assessed.

Local treatment is essentially to increase muscle control and tonus and to correct the deformity by specially designed exercises. The type, vigour, and duration of the exercises must be regulated entirely by the ability of the child to carry them out without fatigue. It is neither necessary nor advisable to fit any form of support or back brace.

In the latter circumstance, where the scoliosis is secondary to a short leg or ankylosis of the hip in malposition, the treatment is that

of the cause Minor degrees of shortening call for nothing more than the raising of the shoe major degrees for the appropriate form of limb equalisation whether it be by leg lengthening or contra lateral leg shortening Tilting of the pelvis due to fusion of the hip in adduction or abduction necessitates corrective osteotomy

Structural, Fixed, or Rigid Scoliosis—In structural scoliosis the series of vertebræ affected remains constantly deviated from the normal spinal axis this lateral deviation being accompanied by a varying degree of wedging and rotation of the vertebræ involved

In view of the relationship of treatment to etiology classification is of importance [1] —

1 *Osteopathic* (congenital hemivertebræ bone diseases or secondary to empyema or thoracoplasty etc)
2 *Neuropathic* (post poliomyelitis spastic diplegia or neurofibromatosis etc)
3 *Myopathic* (congenital or acquired muscular dystrophies etc)
4 *Idiopathic* (origin unknown)

Two forms are of major importance Idiopathic which account for at least 75 per cent of the total and post poliomyelitis which account for 5 to 15 per cent

The first essential of treatment in the growing child is to determine whether or not the deformity whatever its origin is increasing In this respect clinical observation is notoriously unreliable It is therefore necessary to secure radiographs of the whole spine in the standing sitting and lying positions for comparison with films to be taken at three monthly intervals in the future If a later standing film shows increase in the curve the sitting film may be used as a check to eliminate the possibility of the film being due to postural variation The curve shown on the lying film is almost always less than the standing curve but gradually approaches the latter as the deformity becomes more fixed and rigid

If it is clear that the deformity is static no treatment may be required other than careful observation and regular follow up supplemented by exercises designed to improve the general muscle tone posture and vital capacity

If the deformity is shown to be in process of increasing treatment becomes a complex prolonged and highly specialised problem of spinal mechanics often involving radical decisions if the optimum end result is to be obtained It should be recognised at the outset that whereas a scoliosis brace jacket or other apparatus may be used for the support of the established deformity there is as yet no apparatus used in the upright position which will prevent increase of deformity *if the deformity is in process of increasing* Nor have remedial exercises important as they may be in improving muscle tone posture and vital capacity any influence over the progress of the curve in similar conditions It must be admitted therefore that there is no simple conservative measure for preventing further increase of deformity in

[1] This section is to a large extent based on the teaching of Dr John R. Cobb, Hospital for Special Surgery New York. Unpublished work.

the growing child other than recumbency The practical difficulties of treatment in such circumstances are obvious

In recent years improvement in the technique of spinal fusion has stimulated interest in what has previously been regarded as a somewhat hopeless subject Fusion of the affected segment is a practical and efficient method of preventing increase of the deformity and when combined with pre-operative correction and adequate post-operative measures offers the best prospect of a satisfactory outcome to treatment at our disposal at the present time In selecting cases for correction and fusion many points require to be considered including for example —(1) location degree of severity and duration of the curve, (2) age fusion should if possible be avoided before thirteen to fourteen in girls and fourteen to fifteen in boys (3) etiology probably fifty per cent of cases due to anterior poliomyelitis require fusion but only 5 per cent of idiopathic origin

Corrective Plaster Jackets—The Risser turnbuckle jacket is most generally favoured. It is applied from the chin and occiput to the pelvis in high thoracic curves but requires to extend down to one knee in curves located at a lower level Eccentrically placed hinges are incorporated in the front and back of the cast and a turnbuckle on the lateral aspect on the concave side of the curve When the cast is dry it is divided circumferentially at the apex of the curve and an ellipse of plaster removed from the opposite side to the turnbuckle in order to permit bending to take place with successive turns of the turnbuckle Correction of the scoliosis is accomplished in two or three weeks a second jacket may be required to secure complete correction Throughout the corrective process strict attention is directed towards the prevention of pressure sores When reduction is complete the hinges and turnbuckle are removed, all defects in the cast filled with plaster and a large window cut on the posterior aspect to provide access for spinal fusion

Spinal Fusion—The extent of the operation varies in individual cases. Six to eight vertebræ may be fused at a single operation If a more extensive procedure is necessary the primary curve is fused at a first operation and the arthrodesis extended into the secondary curves above and below at a second or even third operation This avoids overlapping of the grafts at the point of most stress namely the apex of the curve

The technique in most common use is a simplified modification of the Hibbs's procedure supplemented by additional bone taken from the *ilium* or tibia The spinous processes and laminæ are exposed and denuded of soft tissue through a mid line incision Multiple flakes of cortical tissue are raised from the spinous processes and laminæ and interlaced in the spaces between the bones Sliver grafts from the tibia or cancellous chips from the ilium are then laid on the bed of rawed spines and laminæ and the interlacing flakes from their surfaces

Recumbency in the original cast is maintained for a period of three months following the final operation Thereafter a new plaster jacket is applied and the patient permitted to resume weight-bearing A rigid celluloid or block leather jacket is necessary for nine to twelve months after operation

KYPHOSIS

Kyphosis occurring in youth may be the result of (1) inadequate supporting musculature (2) vertebral epiphysitis—true adolescent kyphosis or Scheuermann's disease (3) vertebral osteochondritis or Calvé's disease

Kyphosis due to inadequate supporting musculature occurs in children whose general musculature has never reached the normal standard or following some debilitating disease

The treatment which aims at the improvement of muscular development control and tone and prevention of the deformity becoming permanent is conducted on similar lines to those suggested under Postural Scoliosis (p 127) In addition a posterior plaster bed maintaining the deformity in the maximum degree of correction is worn at night until such time as muscular redevelopment can maintain correct posture



Fig 30
Light detachable celluloid jacket in a case of vertebral epiphysitis

Vertebral epiphysitis is an affection of the epiphyses of the vertebral bodies occurring between the age of fourteen and seventeen years of which the clinical manifestations are fatigue backache and dorsal kyphosis of gradual development A lateral radiograph demonstrates wedging of the anterior aspect of the bodies of three to five adjacent dorsal vertebræ together with fragmentation of both the upper and lower epiphyseal plates

In the presence of symptoms and increase of kyphosis recumbency for a period of three to six months in the supine position on a Bradford or Whitman frame or even a bed fitted with fracture boards and a firm mattress is necessary to prevent progressive increase of the deformity Towards the end of this period exercises are instituted and weight-bearing gradually resumed A night-shell maintaining the deformity in the maximum degree of correction should be used for two to three years following the cessation of active treatment A light celluloid jacket for use during the day may be of value in gross deformities (Fig 30)

In the absence of symptoms and with the history that the deformity has remained unaltered for some considerable time the opportunity of reduction has passed In these circumstances treatment is confined to the improvement of posture and muscular development by means of gymnastic exercises In later years such patients especially if they have been engaged in a heavy manual occupation develop symptoms of over use arthritis at the junction of the fixed thoracic curve with the exaggerated compensatory lumbar lordosis In these circumstances

the treatment is that of osteoarthritis, a change of occupation may be necessary and in view of the deformity, a supporting spinal corset or brace may be indicated

Vertebral osteochondritis is an uncommon disease seen in children between five and ten years of age and is characterised by pain fatigue and localised kyphosis in the lumbo dorsal region A lateral radiograph demonstrates the disease to be confined to a single vertebral body which is flattened wedge-shaped and with a marked increase of bony density In contradistinction to tuberculosis the adjacent intervertebral discs are unaffected

The patient is placed on a hyperextension frame and head traction and lower limb skin traction applied for a period of from three to six months Thereafter some form of posterior spinal support or light jacket is necessary for a short period

Senile Kyphosis.—Kyphosis occurring in late adult life is the result of degenerative changes in the intervertebral discs associated with decalcification and wedging of the bodies of the vertebræ in the upper thoracic spine Treatment is unsatisfactory The patients are frequently of spare build and seldom tolerate either the night shell or ambulant spinal brace which might be expected to control the pain and reduce the rate of increase of deformity in the active phase of the disease If possible an attempt should be made in the early stages to secure a compensatory increase in the lumbar curve so that when the affected vertebræ undergo spontaneous fusion and the deformity becomes stationary the patient may be mechanically capable of assuming the upright posture

SPONDYLITIS

Spondylitis Osteoarthritica.—The etiology and pathology of osteo arthritis of the spine differs in no way from osteoarthritis affecting other joints It occurs in that part of the spine which is most mobile and therefore most liable to the trauma of over-exertion It is thus seen most commonly in the lumbar spine in males past middle life whose occupations such as coal mining and dock labouring have incurred strain over a period of many years Postural defects due to occupation or obesity a previous crush fracture of a vertebral body or shortening of a limb the result of congenital abnormality disease or malunited fracture compensated by a lumbar scoliosis are all factors which may contribute to the degenerative process

It can be demonstrated radiologically that considerable arthritic change may be present in the lumbar spine and the patient remain symptomless Some factor such as a recent minor injury increase in weight or the presence of an active toxic focus is usually responsible for the onset of the symptoms which are due to the locking of osteo phytic outgrowths pressure on nerve roots or secondary fibrositis in the surrounding muscles and ligaments

Treatment is by general and local therapeutic measures

The general treatment is directed towards the correction of postural defects and the eradication of toxic foci If possible a change to a

less arduous occupation should be effected Reduction of the weight by suitable dietetic measures often gives considerable benefit

The local treatment must be varied according to the stage of the disease The common physiotherapeutic measures of massage radiant heat diathermy and short-wave therapy are all of service in relieving pain and the accompanying muscular spasm When the acute phase has passed to these methods of producing local heat are added gentle active spinal exercises to maintain the maximum range of mobility Certain cases, especially those which are improving and which have retained a fair range of movement and in whose X rays no obvious bony ankylosis between osteophytes can be demonstrated react well to manipulation under anaesthesia The lumbar spine is gently flexed and extended and put through the movement of rotation in both directions The procedure is carried out gently and with the utmost care for force which may be used with safety in the manipulation of a spine with a less extreme pathology is quite unjustifiable in osteo-arthritic cases In extreme cases which have failed to improve in spite of treatment alleviation of symptoms may be obtained by fitting a supporting spinal brace

Spondylitis Ankylopoietica. —This distressing condition which appears to be encountered with increasing frequency is a disease of young adult males It is unfortunately rarely seen at an early stage because the symptoms vague joint and muscle pains do not seem to warrant detailed investigation When surgical opinion is sought the patient s general condition has deteriorated he complains of pain in the back and of increasing stiffness and flexion deformity of the spine The first radiological evidence of the disease is seen in the sacro-iliac joints which become ankylosed at an early stage As the disease progresses the intervertebral and costovertebral joints are affected with rapidly increasing dorsal kyphosis and fixation of the chest wall If unchecked the disease may extend peripherally to the hip joints and even to the knees and shoulders

Modern developments in radiotherapy have produced a marked change in the prognosis of this most potentially crippling of the common diseases Deep therapy in adequate dosage not only relieves the pain but arrests the progress of the disease in the earliest cases some improvement in the range of movement in the lumbar spine can even be anticipated In the average case bony ankylosis of the spine must be expected, and as deep therapy has no effect upon posture it is most important that ankylosis occurs in the optimum functional position It is thus essential that deformity provided it has not reached the stage of ankylosis be corrected by gradual methods the temptation to produce reduction by manipulation under anaesthesia must be resisted. The patient is treated in recumbency in a bed fitted with fracture boards with or without the addition of head traction (Fig 54) or with serial posterior plaster shells until the maximum improvement has been attained On return to weight-bearing a light spinal brace is fitted. Throughout the period of correction and regularly thereafter deep breathing exercises to maintain the respiratory excursion together with postural and general exercises are practised.

LOW BACK PAIN

In considering the treatment of low back pain it will be remembered that the hopelessness and confusion which have characterised this problem in the past have been essentially due to the failure to form an accurate diagnosis Persistent aching pain in the lower lumbar and sacro-iliac regions may be due to pathological changes in the joints ligaments and muscles but almost identical symptomatology may arise from gynæcological abnormalities chronic constipation or diseases of the urinary tract It is therefore essential that no orthopædic treatment be undertaken prior to the most complete investigation There are few conditions in surgery in which so much importance attaches to the accuracy and detail of the history and to meticulous clinical examination

Clinical History —The patient must be questioned carefully to elicit all relevant features relating to the pain as follows —

(*a*) Type Dull aching pain is characteristic of almost all types of chronic low back pain Sharp agonising pain may indicate an acute lesion or an acute attack of lumbar fibrositis or myofascitis

(*b*) Situation The exact situation of the pain very frequently indicates the site of the causative lesion

(*c*) Radiation Pain radiating into the lateral aspect of the calf and foot for example would indicate pressure on the first sacral root and would direct attention to the disc at the lumbo-sacral junction

(*d*) Duration The duration is important and indicates whether the condition is acute or chronic

(*e*) Mode of onset It is essential to know whether the condition was gradual in onset or whether the onset was sudden and if it was preceded by trauma

In female patients the relationship of the pain to a previous pregnancy will be noted

(*f*) Presence of stiffness Stiffness in association with pain may indicate the presence of degenerative arthritic change in the joints especially if it is present in the morning or after a period of rest disappearing on the resumption of activity

(*g*) Influence of other factors Patients suffering from sacro-iliac strain for example frequently complain of increase of pain while lying in the supine position or upon turning over in bed they are unable to sit on a hard chair only obtaining relief by taking the body weight on the sound side Pain radiating down the leg on coughing or straining at stool suggests a root lesion as may be produced by the retropulsion of an intervertebral disc

These examples merely serve to indicate the influence which the intelligent interpretation of a most complete history may have in the final diagnosis

Examination of the Patient.—The patient is stripped and examined in both the erect and recumbent positions

The general posture weight muscular development and tone are noted Careful observation is necessary for some minor abnormality of posture which the patient adopts such as a slight degree of flexion at the hip and knee which relaxes the hamstrings may be due to chronic sacro iliac strain on the side concerned

The spinal curves are examined and any deviation from the normal noted A slight tilt of the pelvis which has resulted from the shortening of one limb and which has caused a compensatory scoliosis may be the error of posture responsible for the symptoms (Fig 40)

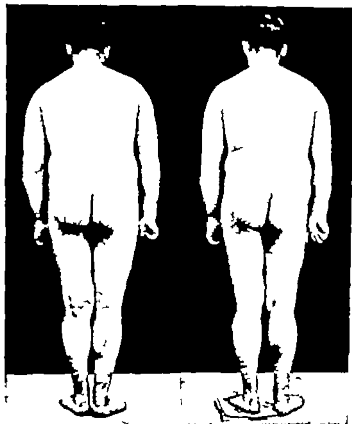


Fig 40

Low back pain of many years' duration due to congenital shortness of the left leg The symptoms were relieved within a few days after correcting his posture by raising the boot.

The movements of flexion extension lateral flexion and rotation are carried out and abnormalities such as rigidity muscle spasm or the production of pain noted.

The patient is asked to indicate the exact site of both pain and tenderness In lumbo-sacral lesions for example pressure over the fourth and fifth spinous processes produces pain whereas in sacro iliac strain tenderness is limited to the region of the posterior superior spine and the posterior sacro iliac ligaments Areas of myofascial tenderness may be of importance in arriving at the final diagnosis

In the recumbent position the effect of passive movements on both the spine and hip joints is observed, noting especially the reaction

of the patient to the movement of the sacro iliac and lumbo-sacral joints and to the stretching of the sciatic nerve produced by straight leg raising

It is essential to remember that from the viewpoint of accurate diagnosis the value of radiographs of the lumbar spine and sacro iliac joints depends not only upon experience of interpretation but upon the technical skill of production demonstrated in the plates

Sacro iliac Strain

This diagnosis is often applied to undiagnosed low back pain of obscure origin It is however a clearly defined clinical entity in which the response to treatment is excellent in a large proportion of cases

There is a small but measurable range of movement at the sacro-iliac joints This may be proved by measuring the distance between the posterior superior spines of the iliac bones in the prone position and repeating the measurement in the sitting position It will be found that the figures obtained may differ by as much as half an inch

The opposing sacral and iliac surfaces of the joint are irregular in construction but so arranged that the opposing irregularities fit together accurately The opposing surfaces are smoother in the female joint and thus the range of movement is greater in the female attaining its maximum range in childbirth but the structure of the joint must of necessity be weaker

The condition to which the term sacro-iliac strain is applied occurs when as a result of some mechanical force or injury the joint becomes locked at one or other of the extremes of range of movement It may frequently be demonstrated in spare subjects that the ilium is displaced forward in relation to the sacrum by palpation of the posterior superior spines when it will be noted that the spine on the affected side is less prominent than the spine of the normal side

The locking may occur as a result of the stress incurred while lifting a heavy weight or during pregnancy when the shearing strain due to the increase of lumbar lordosis in addition to the laxity of the sacro-iliac ligaments makes displacement of the joint a matter of common occurrence

Acute sacro-iliac strain is characterised by severe pain in the joint immobility of the low back region and muscular spasm associated with a recent twist or strain *Chronic sacro-iliac strain* is the result of failure to recognise the acute condition or is associated with childbirth or with an operation performed in the lithotomy position, or with a progressive increase of weight

The treatment of both the acute and chronic varieties is essentially by manipulation designed to correct the displacement and restore mobility together with physio therapeutic measures and spinal exercises to increase muscle tone and correct faulty posture No manipulative treatment however is undertaken until the possibility of tuberculosis secondary malignant deposits or other gross abnormality has been eliminated by X ray examination

A single manipulation will usually *produce a dramatic result* in the acute case and no further treatment may be indicated but in the chronic form there are usually other etiological factors such as a postural defect short limb or excessive weight which must be overcome if anything more than a transient improvement is to be obtained

The manipulation is carried out under general anæsthesia except in certain selected cases in which anæsthesia may be unnecessary



FIG 41
Manipulation of sacro-iliac joint. (*Mennell.*)

The patient is turned on to the sound side one hand is placed on the shoulder while the other hand grasps the limb of the affected side behind the knee Pressure is exerted in opposite directions until the spinal column is locked in the position of full rotation When full rotation has been obtained the extra pressure exerted by the hand grasping the knee is transmitted through the sacro iliac joint which moves from the locked position with an audible click (Fig 41)

Finally there exists a group of cases in which the diagnosis has been established beyond doubt but which have failed to react to conservative measures These selected cases are treated by arthrodesis of the joint an operation which produces excellent results without residual impairment of spinal mobility The joint is approached through a curved incision following the posterior two thirds of the iliac crest The exact position of the joint is defined and a rectangular window of bone removed from the overlying ilium exposing the sacral articular surface Following the removal of the articular cartilage from the sacrum and the exposure of cancellous bone the rectangular block of ilium is replaced and countersunk into the sacrum thus fusing the joint (Fig 44) At the completion of the operation the patient is immobilised in a previously prepared posterior plaster shell for a period of two to three months by which time arthrodesis is complete

LUMBO-SACRAL STRAIN

Lumbo-sacral strain occurs in both acute and chronic forms

The acute form may be caused by a sudden blow forcing the junction into positions beyond the normal range of movement by an effort to prevent a heavy article from falling or by a sudden body movement while attempting to regain lost balance The spinal muscles are caught off guard and thus the ligaments sustain the full force of the injury

The chronic form is usually insidious in onset but may follow an acute strain which has been unrecognised or untreated It occurs in those

with a long weak back with poor musculature and increased lumbar lordosis or in those usually women whose increase in weight has taken the form of a pendulous abdomen The maintenance of body balance necessitates an exaggeration of lumbar lordosis with consequent increase of the shearing strain at the lumbo-sacral angle

It has been customary in the past to attribute the symptoms in such cases in both the acute and chronic varieties to ligamentous strain Modern opinion tends to the view that the underlying pathology is frequently an injury *to the intervertebral disc and it is now accepted* that lesions of the disc are a common source of low back pain which need not of necessity be associated with pain in the sciatic distribution Furthermore the lumbo sacral joints are not only the common site of congenital anomalies but are the inevitable subject of malalignment in degenerative changes in the intervertebral disc producing narrowing of the disc space, both conditions predispose to osteoarthritis (Fig 42)



FIG 42

Degenerative changes in the intervertebral disc of the lumbo-sacral junction producing loss of disc space with consequent malalignment of the intervertebral joints. The symptoms were those of arthritis of the joints there were no signs of root pressure Treatment lumbo-sacral fusion.

In the acute stage rest in bed for a period of two to six weeks is essential The patient should lie in a bed fitted with fracture boards and pillows are placed beneath the knees and lumbar spine When acute symptoms have subsided massage radiant heat and diathermy are of assistance and with improvement graduated spinal and postural exercises are instituted.

Chronic lumbo-sacral strain presents a more complex problem and dramatic results are not to be expected. It is necessary to seek the underlying cause before local treatment is commenced Such factors as a postural defect due to deformity of a lower limb increase of weight causing an exaggeration of the lumbar curve and active toxic foci must receive attention Thereafter exercises designed to flatten the lumbar curve increase muscle tone and improve posture form the essential local treatment The fitting of a back brace is rarely necessary or desirable but those patients with pendulous abdomens frequently benefit from the support of a lumbo-sacral belt or strong corset

Manipulation as an isolated measure can only produce transient

improvement in chronic lumbo-sacral strain but in long-standing cases especially where there is evidence of initial trauma *is of value* in mobilising joints and breaking down adhesions prior to back and postural exercises The manipulation performed is similar to that described on p 136

Where symptoms of long standing can be shown to be due to arthritis of the inter vertebral joints conservative measures are unlikely to produce more than temporary relief In these circumstances there is strong indication for lumbo sacral fusion

Spondylolisthesis

Spondylolisthesis is a forward displacement of the fifth lumbar vertebra and spinal column on the sacrum—the common variety—or of the fourth lumbar vertebra and the spinal column on the fifth lumbar vertebra The displacement may be gradual in onset or may be initiated by trauma but the underlying etiology is a developmental failure of fusion between the anterior superior and the posterior inferior articular segments of the neural arch The forward displacement of the vertebral body and the gap in the lamina are clearly demonstrated in a lateral radiograph

When the symptoms are mild and the condition apparently not progressive treatment is strictly conservative and consists of change to a sedentary occupation, reduction of weight postural training and exercises designed to reduce the lumbar lordosis and the fitting of a spinal brace lumbo sacral belt or strong corset Unfortunately in many cases the condition is progressive and the symptoms severe they may even include pain in the sciatic distribution accompanied by signs of direct pressure on nerve roots In these circumstances *operation is indicated It consists of fusion of the third fourth* and fifth lumbar vertebræ to the sacrum by the posterior route by a technique similar to that described under Scoliosis (p 120) but in the presence of neurological signs the nerve roots affected must be freed from pressure before the spinal fusion is carried out

Sacralisation of the Fifth Lumbar Vertebra

This term is applied to a bony conformation in which one or both of the transverse processes of the fifth lumbar vertebra is long and wing-shaped and either articulates with or *is fused to the sacrum or* ilium or both. It is a condition said to arise in 3 5 per cent of normal individuals and therefore the presence of this abnormality in the radiograph taken in the routine examination of a patient suffering from low back pain must not necessarily be taken as the explanation of the presence of symptoms Symptoms however may arise as a result of arthritis (Fig 43) or locking of the new joint irritation of an associated bursa or the more usual sacro iliac strain on the affected *or even contra lateral side*, which results from the distraction

produced by the leverage of the abnormal process in lateral movements of the spine

Acute cases, especially those whose symptoms are associated with a recent minor injury should be treated by an initial period of rest in a bed fitted with a firm mattress together with such physio therapeutic measures as diathermy or radiant heat After a period of two to three weeks the patient can usually resume weight bearing and begin a course of graduated spinal exercises If no improvement has resulted a manipulation of both sacro iliac joints together with the



FIG 43

Unilateral sacralisation of the transverse process of the fifth lumbar vertebra. Note the *presence of sclerosis in the* adjacent surfaces of the joint between the transverse process and the sacrum and also in the adjacent surfaces of the sacro-iliac joint.

lumbar spine may produce relief which is maintained if followed by back and postural exercises

A certain number of cases of established diagnosis are resistant to all forms of conservative treatment In these cases relief is obtained only after resection of the abnormal process (Fig 44)

SCIATICA ASSOCIATED WITH LOW BACK PAIN

Pain in the distribution of the sciatic nerve associated with low back pain may be —

(1) Reflex when it may be caused by such conditions as lumbar arthritis, sacro iliac strain or sacralisation In these circum stances the sciatica is characterised by an absence of neuro-logical signs Treatment is that of the cause

(2) *Due to pressure on a root* This is the most common form of sciatica and is due to direct pressure on a nerve root usually the fourth or fifth lumbar or the first sacral by the retropulsion of an intervertebral disc This form of sciatica is characterised by low back pain with muscle spasm scoliosis and restriction of movement in the lumbar spine Neurological features include sharp radiating pain on coughing or straining at stool diminution of sensation on the lateral aspect of the calf and foot weakness of muscles especially the dorsiflexor of the great toe and a diminished or absent ankle jerk



Fig 44

After a ten years history of severe low back pain the patient was rendered completely symptomless by resection of the abnormal process and arthrodesis of the sacro-iliac joint. The arrows indicate the rectangular block of bone counter sunk into the sacrum.

In an initial or in a mild attack rest in a bed fitted with fracture boards will frequently effect alleviation of symptoms in a period of *two to six weeks* *If relief is not obtained*, in a more severe attack or as an alternative to bed rest where such is not possible more complete immobilisation may be obtained by the use of an ambulatory plaster jacket reaching down to the knee on the affected side The ordinary plaster jacket used for fractures of the spine is useless it does not produce complete immobilisation of the lumbo-sacral joint If necessary a general anaesthetic is administered to relax the muscle spasm and permit the normal lumbar lordosis to be reconstituted and the scoliosis reduced The patient is placed on the pelvic rest of an orthopaedic table and the limbs permitted to sag towards the floor (Fig 45) this undoes the scoliosis and reconstitutes the lumbar curve

The affected leg is now raised to the neutral position of hip flexion and extension, abduction and adduction (Fig 46) A closely moulded plaster spica which reaches from the nipples to immediately above the

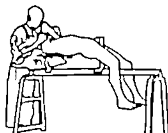


Fig 4

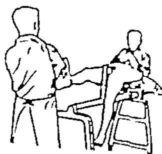


Fig 46

knee is applied while the correction of the lumbar spine is maintained by the sound limb which remains extended throughout the procedure (Fig 47)

In a large proportion of cases this form of immobilisation will produce immediate relief from pain If the method fails to give relief and in the occasional case in which symptoms are aggravated it should be discontinued In ordinary circumstances the jacket is retained for six weeks its removal is followed by a very carefully graduated course of exercises designed to remobilise the lumbar spine and re-develop the protective musculature Actions known to aggravate the condition such as lifting or carrying heavy weights digging or starting a car by hand are avoided. The return to the heaviest of heavy manual occupations may be contraindicated

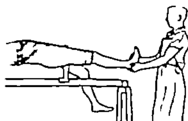


Fig 47

If conservative measures fail and in cases which suffer repeated relapses radical operation which consists of excision of the protruding disc sometimes with the addition of lumbo-sacral fusion is necessary to effect a cure

I S S

INJURIES OF THE SPINE

Injuries to the spine constitute an important problem of casualty work. Their treatment demands special consideration in view of the risk of involvement of the spinal cord

First Aid.—When an injury to the spine is suspected, the greatest care must be taken in the examination and transport of the casualty for undue disturbance may lead to exaggeration of the displacement and inflict damage on the spinal cord The examination at this stage should therefore be no more extensive than is required to make a presumptive diagnosis of spinal injury and to determine the approximate level of the lesion The casualty should not be moved from the scene of the accident until a stretcher has been obtained and must be conveyed thence to hospital without further disturbance

There is no risk of causing further damage to the spinal cord providing the spinal column is not flexed or hyperextended whilst the

casualty is lifted and transported to hospital in the supine position This position should be maintained until there is an opportunity of making a complete clinical and radiographic examination

Fractures of the Atlas and Axis.—Fractures of the atlas generally result from a fall on to the head. The fracture occurs through the weak part of the ring immediately behind the lateral mass and in some cases there may be an associated fracture of the pedicles of the axis (Fig 48)



FIG 48

Fracture of the posterior arch of the atlas and the pedicles of the axis, caused by a heavy sack of flour falling on to the head.

Fractures of the axis may be caused by flexion or hyperextension violence applied to the head Hyperextension injuries are more common in elderly patients and are caused by a fall on to the forehead. The axis fractures through the base of the odontoid process and it and the atlas are displaced backwards on the axis (Fig 49) In flexion injuries the axis fractures through its pedicles immediately behind the body and the body of the axis and the atlas are displaced forward (Fig 50)

The cord is seldom injured in fracture dislocations at this level apart from the rare anterior dislocation of the atlas on the axis without fracture of the odontoid which is usually fatal

Treatment—There is little or no displacement in isolated fractures of the arch of the atlas and treatment is by two months immobilisation in a Minerva plaster jacket which extends from the pelvis to the top of the head The most satisfactory method is that advised by Watson-Jones A strip of wood 3 in wide by 1 in thick is fixed to a wooden bench so as to project about 12 in beyond its end. The patient is placed supine the end of the wood strip reaching to the base of the neck The surgeon supports the head in the neutral position The plaster cast is then applied over a stockinet vest and should extend over the forehead to the level of the eyebrows The plaster is cut away beneath the chin to allow free movement of the lower jaw (Fig 51)

In fracture-dislocations of the atlas and axis the displacement is

corrected as far as possible by gently flexing or extending the neck according to the type of injury The reduction is performed under omnopon-scopolamine narcosis supplemented if necessary by a small dose of pentothal The position is



Fig. 49
Hyperextension injury of upper cervical spine There is a fracture of the odontoid process, and it and the atlas are displaced posteriorly

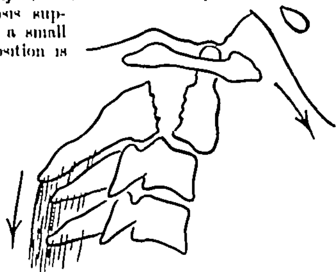


Fig. 50
Hyperflexion injury of upper cervical spine The pedicles of the axis are fractured over the "wedge" formed by the superior articular facets of the third cervical vertebra. The body of the axis and the atlas are displaced anteriorly

checked by radiographic examination before applying a plaster jacket as described here The plaster jacket is retained for at least three months

Injuries of Lower Cervical Spine—Compression fractures and subluxations are most frequent in the fifth and sixth cervical vertebra They are caused by flexion violence and are seldom complicated by a cord injury The deformity can be corrected by hyperextending the *neck* and applying a plaster jacket as described here Care must be taken not to tilt the *head* back or the patient may be unable to swallow The plaster is retained for two months



Fig 51
Plaster jacket for injuries of the cervical spine The head must not be fully extended or the patient may be unable to swallow The plaster is cut away beneath the chin.

Dislocation of the cervical spine commonly occurs without bony injury and is associated with locking of the articular processes which must be disengaged by powerful traction before the displacement can be corrected (Figs 52 and 53) As a rule the spinal cord is contused or compressed and there is paraplegia

Treatment—The safest method of reduction is by the application of skull traction under local anaesthesia A small incision is made over

each temporal bone at a point ½ in anterior and 2 in above the external auditory meatus A small disc of the outer table of the skull is removed by means of a trephine and a skull calliper is applied



FIG 52

Dislocation of cervical spine. The descending articular processes of C 6 are locked in front of the ascending processes of C 7



FIG. 53

Same case as Fig. 5_. Skull traction has been applied and the articular processes are now disengaged.

so that the flanges rest under the outer table The two halves of the calliper are locked together by a cross bar and 15 to 20 lb traction is applied to it according to the muscular development of the patient

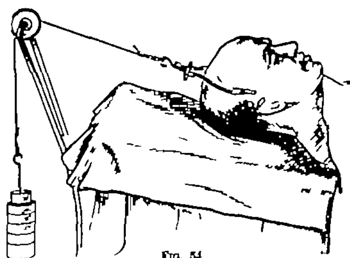


FIG. 54

Method of application of skull traction.

(Fig 54) Traction is first applied with the head in neutral position Radiographs are taken at frequent intervals until the articular processes are seen to be disengaged (Fig 53) The neck is then extended by

lowering the pulley at the head of the bed and the traction is reduced to 6 lb Prolonged heavy traction should be avoided it prevents satisfactory healing of the torn ligaments and predisposes to redislocation Providing there is no serious cord injury a plaster jacket may be applied after two or three weeks If paraplegia persists traction must be continued, for it is impossible to apply a plaster jacket without causing severe bed sores in the anæsthetic skin The immobilisation is continued for at least three months

Injuries of the Thoracic and Lumbar Spine—The great majority of these fractures are flexion injuries Two-thirds of all the fractures



Fig 55

Simple compression fracture of first lumbar vertebra treated by two weeks bed rest and by hyperextension exercises.

occur in the region of greatest mobility namely the twelfth thoracic and first and second lumbar vertebræ For the purpose of treatment these injuries may be divided into (1) Stable fractures in which there is a minimal or moderate degree of anterior or lateral wedging of the vertebral body (Fig 55) In these fractures the cord is not damaged and there is no risk of increasing deformity (2) Unstable fracture—dislocations and subluxations including severe wedge fractures in which the interspinous ligament is ruptured (Fig 56) In this group the cord is often damaged and there is a risk of increasing deformity even after prolonged immobilisation in a plaster jacket

Treatment of Stable Fractures—Until recently the accepted method

of treatment was to open out the compressed vertebra by hyper extending the spine and to apply a plaster jacket in this position for four to six months until there was firm consolidation of the fracture Experience has shown that minor degrees of wedging of a vertebra are not incompatible with full functional recovery and excellent results are obtained by concentrating on the associated soft tissue injury

The patient is kept in bed on a firm mattress for three to four weeks until pain is relieved Exercises for the spinal muscles are commenced



FIG 56

Severe compression fracture of second lumbar vertebra treated by six months immobilisation in plaster No attempt was made to correct the deformity Note commencing spontaneous fusion between first and second lumbar vertebræ.

within a few days of the injury and must be practised regularly They are carried out in the prone position and consist in raising the head and shoulders and hyperextending the lower limbs (Fig 57) At the fourth week the patient is allowed up and an intensive programme of rehabilitation is commenced and continued until he is fit for his former occupation

Treatment of Unstable Fracture—Dislocation and Subluxations—A residual deformity cannot be avoided in this group because the interspinous ligament is ruptured and the intervertebral disc disorganised. Furthermore there is a risk of increasing deformity

even after adequate immobilisation When there is no cord injury the most satisfactory results are obtained with a limited fusion of the dislocated vertebra and the vertebra immediately below it This may be achieved by a surgical fusion of the spinous processes and laminæ or by allowing a controlled approximation of the vertebral bodies so that anterior fusion can occur (Fig 56)

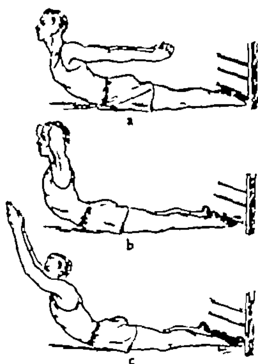


Fig 57
Hyperextension exercises following spinal injury The exercise is commenced with the hands clasped behind the back, as in a and the effort demanded is increased by extending the arms above the head.

In the latter method a plaster jacket is applied with the spine in neutral position as soon as the patient has recovered from the immediate effects of the injury There is no risk of damaging the cord providing the spine is not flexed The patient sits on a low stool with an assistant holding the head and spine steady The iliac crests and prominent spinous processes at the level of dislocation are padded with adhesive felt and the trunk covered with two layers of stockinet The jacket extends from the manubrium sterni to the symphysis pubis in front and the angle of the scapula to the lower part of the sacrum behind and is well moulded to the bony prominences (Fig 58) When the patient is returned to bed he should be placed supine on a firm mattress until the plaster is dry He is then encouraged to turn from side to side and within a few days exercises are commenced for the spinal muscles as described in the treatment of stable fractures of the spine The plaster is retained until there is X ray evidence of a satisfactory fusion of the bodies of the dislocated vertebræ which may take six months or even longer Many surgeons advocate a fusion of the laminæ and spinous processes of the dislocated vertebræ within a few days of the injury Surgical fusion occurs with greater rapidity than a spontaneous fusion and may reduce appreciably the period of immobilisation



Fig. 58
Plaster jacket for unstable fractures of lower thoracic and lumbar spine

may be caused by a massive intervertebral disc protusion or an extradural hæmatoma (Figs 59 and 60) or a fractured articular process may be driven into the spinal canal In these circumstances a laminectomy is indicated when the paralysis is incomplete and there is no evidence of recovery in the first two or three days after injury Evidence of continued pressure on the cord may be obtained by spinal manometry The patient is placed on his side with the vertebral column strictly horizontal lumbar puncture is performed and the needle connected by a short length of tubing with a fine bore glass tube which acts as a manometer Normally with the patient at rest a pressure of 5 to 12 cm may be recorded and if the cervical veins are temporarily occluded by firm pressure at the base of the neck the pressure may rise to 20 to 30 cm (Queckenstedt) If no rise occurs a spinal block may be diagnosed Bone fragments and extruded disc material may however cause pressure on the cord and not completely occlude the spinal canal In these circumstances the Queckenstedt test will be negative and the true state of affairs can only be demonstrated by myelography (Fig 60)



Fig 60
Myelography after injection of lipiodol into lumbar theca, showing complete block at the level of the herniated disc Patient treated by laminectomy with almost complete recovery of paraplegia.

Palliative Treatment—In paraplegia the essentials of treatment are the prevention of bed sores and the care of the paralysed bowel and bladder Continuous attention and zealous care are necessary to the attainment of these objectives Indeed the treatment of paraplegia provides the greatest possible test of the efficacy of nursing methods

Apart from medical and nursing treatment patients with paraplegia require much physical rehabilitation and present difficult problems in vocational training and resettlement

Prevention of Bed Sores—In a paraplegic patient deep bed sores will develop in the anæsthetic skin with great rapidity unless skilled nursing care is available Common sites are the sacrum trochanters and anterior superior iliac spines

The patient must be turned every two hours so that continuous pressure is prevented on any one area In cervical injuries he should be nursed on a sorbo rubber mattress and in injuries of the thoracic

and lumbar spine in plaster shells (see p 148) The patient must not be allowed to lie in a wet or soiled bed and the skin over the bony prominences must be kept dry hardened by frequent applications of spirit and well powdered

If a bed sore develops it is dusted lightly with penicillin sulpha thiazole powder and covered with dry sterile gauze The turning is continued as before otherwise larger and deeper sores will appear in other areas

Care of the Bowel—In most cases there is incontinence of fæces due to paralysis of the anal sphincter When the patient is nursed in a plaster bed a bedpan can be kept constantly in position If an ordinary bed is used he must not be allowed to lie on soiled bed linen which is a potent cause of bed sores The diet should have a low residue and be rich in fat and protein If there is much loss of sub cutaneous fat it is very difficult to prevent bed sores over the bony prominences Purgatives are best avoided and the bowel should be emptied by an enema as required

Care of the Bladder—Ascending infection of the urinary tract from the paralysed bladder is the main cause of severe invalidity and death in spinal cord lesions It presents a problem for which as yet there is no completely satisfactory solution

At the outset there is retention of urine After a few weeks the patient may gain imperfect control in partial lesions of the cord but the best that can be hoped for in complete lesions is a type of reflex micturition This can only be achieved with a bladder of adequate capacity and in the absence of severe infection

It is not necessary to drain the bladder immediately following the injury It can be safely allowed to distend for twenty four hours or even longer until such time as the patient is transported to suitable surgical surroundings A choice must then be made between an indwelling catheter or a suprapubic cystotomy Each method has its advocates and should be used in conjunction with some form of tidal drainage If an indwelling catheter is used it is introduced under the strictest aseptic precautions and changed weekly The objection to its use is the risk of a urethritis and spread of infection from the posterior urethra to the kidneys

Suprapubic cystotomy is simple and can be performed without anæsthesia if the cord lesion extends up to the tenth thoracic segment The bladder is allowed to distend and an opening is made by a trocar at the highest level of bladder dullness or the mid point between the umbilicus and symphysis pubis whichever is the lower A 16 F catheter is inserted and changed after fourteen days and subsequently once a week under strict aseptic precautions Infection cannot be entirely avoided with a suprapubic cystotomy but there is possibly less risk of severe infection than with a urethral catheter

Many different types of tidal drainage are available None of them is foolproof They require constant supervision and their method of operation must be understood by everyone concerned including the patient (see p 688) The fluids used for irrigation are ½ per cent acetic acid, 4 per cent boric acid or solution G (Suby) Solution G may dissolve small phosphatic calculi but is ineffective in the presence

of heavy infection The irrigation fluid passes into the system through a drip connection as the bladder fills with urine and fluid the pressure within it rises until the syphon is set in operation thus emptying the bladder If the apparatus is working properly fluid will rise and fall in the shorter limb of the syphon with each respiration

Calculi are liable to form in the bladder and renal pelvis especially in the presence of infection They may be prevented by careful catheterisation forcing fluids turning the patient frequently so that urine is not allowed to stagnate in the posterior part of the renal pelvis If the urine becomes infected one of the sulphonamides should be administered for a short period

Care of the Joints —All joints of the paralysed limbs should be put through a full range of movement at least once a day In most cases it is possible to prevent severe contractures by regular passive movements

Severe flexor spasms may be the cause of much suffering They can be relieved provided the cord lesion is complete by injecting 5 to 6 c c of absolute alcohol into the spinal theca at the first lumbar interspace The patient lies on his side on an operating table which is tilted head down approximately 20°, so that the alcohol runs towards the sacral end of the spinal canal.

Physical Rehabilitation —Exercises of the normal parts of the body are encouraged from the earliest days after injury Particularly important are exercises for the non paralysed spinal muscles The patient should be allowed up on a wheel chair as soon as the spinal injury permits *It is usually possible three to four months after injury* More determined patients can be taught to walk for short distances with callipers and crutches even when both lower limbs are totally paralysed.

Occupational therapy is introduced at an early stage It promotes dexterity of the fingers and arms and greatly improves the patient s morale Vocational training is added later with the object of returning the patient to a new occupation R B

OPERATIONS ON THE SPINAL CORD

Laminectomy —This is the route of access to the cord and its membranes The patient lies prone with the affected part of the spine flexed. Pillows are placed at the sides under the pelvis and chest to facilitate respiration *A straight midline incision is made 6 or 8 in long* and is deepened to expose the spinous processes The muscles of the erector spinæ group are elevated from the sides of the spinous processes and posterior aspects of the laminæ preferably by means of a chisel or osteotome working against the bones and are held apart by powerful self retaining retractors

The spinous processes to be removed are then identified, cleared from those above and below by division of the interspinous ligaments and cut through at their bases by heavy laminectomy forceps An extra spine may be removed above and below to give better exposure

The laminæ are removed piecemeal by means of a rongeur forceps It is best to start at the lower end of the exposure and work upwards

with care to avoid injury to the cord especially if it is displaced by a tumour Some bleeding occurs from the cancellous spaces and adjacent soft tissues and must be arrested by bone wax or other means before the dura is opened

The dura mater is exposed by dissecting off the remains of the ligamentum flavum. If the dura is to be opened it should be picked up by two fine hooks and opened with care to avoid damage to the cord. A fine director is then inserted and the opening enlarged.

When the operation has been completed the dura is closed by fine silk stitches the muscles are drawn together to obliterate the dead spaces and the aponeurosis and integuments are closed in the usual way If the laminectomy has been an extensive one especially if in the cervical or lumbar regions a brace or other support should be worn for several months afterwards.

Spinal Tumours.—The method of access is by laminectomy If the tumour is extradural and of benign character it can sometimes be removed completely or partly If it is inaccessible a wide laminectomy may serve to relieve the pressure on the cord

The spinal tumours most responsive to surgical treatment are the intradural extramedullary tumours. These are chiefly meningiomas and neurinomas and are usually situated in close relationship to the posterior nerve roots To gain access the dura mater must be opened The tumour which is encapsulated is then dissected free and removed along with the affected nerve root and any involved part of the dura

If the tumour lies anteriorly a slip of the ligamentum denticulatum must be divided and used to rotate the cord very gently to gain access If this is not sufficient it may be necessary to sacrifice a posterior root and even an anterior root to mobilise the cord sufficiently

Intramedullary tumours are generally invasive gliomas arising near the central canal They may occasionally be removed by splitting the cord longitudinally and carefully dissecting out the tumour but recovery is apt to be disappointing More frequently they are irremovable and in these cases if the dura is left open as a decompression some immediate improvement may be obtained and subsequent X ray therapy may delay the progress of the growth Sometimes a glioma undergoes cystic degeneration and in such a case the pressure on the long fibre tracts may be relieved by incising the cyst to one side of the midline Similar treatment may be advised for syringomyelia though X radiation alone gives some benefit

Herniation of Nucleus Pulposus.—Retropulsion (herniation) of the nucleus pulposus may occur at any level of the spine but is most frequent in the lower lumbar region where it is the most common single cause of radicular sciatica (see p 140) In the sciatic type the diagnosis is made on clinical grounds (myelography air or lipiodol fails to demonstrate about 20 per cent of cases) Conservative treatment (p 140) gives a high proportion of recoveries and should be used initially With recurrent symptoms particularly in active individuals or when neurological signs are marked indicating gross nerve root pressure operative intervention should be advised.

Under general anaesthesia with the lumbar spine well flexed the erector spinae muscles are stripped laterally on the affected side from

the spines and laminæ of the lumbo-sacral region the required inter laminar space opened by dissecting away the ligamentum flavum A small piece of lamina may have to be nibbled away to expose the affected root adequately The root usually lies on the summit of the protrusion and when it and the spinal dura have been retracted medially the protrusion in most cases comes into view The thin remnant of the annulus fibrosus is then incised when the protrusion and part of the nucleus pulposus tend to herniate through the opening made and may be removed often as one continuous mass The remains of the nucleus should then be removed from the centre of the disc by punch forceps (sphenoid type) curved to allow access to all parts of the nucleus The cartilaginous plates on the vertebral bodies are often then removed at least in part by curette through the same opening in the annulus Relief from pain is usually rapid the patient being up in ten days and exercises then restore spinal mobility in a few weeks Occasionally a hemi or even complete laminectomy may be required at this level and convalescence is longer In a few cases where there is secondary arthritis a local spinal fusion may be needed to prevent persistent low back pain In the upper levels the symptoms may be those of an extradural tumour and diagnosis is made by myelography Treatment is by removal using a hemi or full laminectomy In the cervical region the symptoms may be those of a brachial radiculitis These cases frequently respond well to light halter traction on the head followed by fixation of the head and neck for several weeks If this fails the protrusion may be removed through a small hemi laminectomy

Operations for Intractable Pain—For intractable pain in the trunk or limbs in conditions for which no curative treatment is possible as an alternative to heavy morphinisation it is sometimes justifiable to carry out operative section of the sensory pathways

For pain in a very limited area section of the appropriate posterior nerve roots through a laminectomy may suffice A less certain method is the subarachnoid injection of a small quantity of alcohol with the patient so postured that the roots to be anæsthetised are highest and so bathed by the light alcohol In a limb this procedure has the disadvantage of resulting in loss of useful function. In most cases, therefore a preferable method is to divide the pain-conducting fibres as they lie in the antero-lateral tract This procedure abolishes pain and temperature sensation without loss of positional sense

The cord is exposed by laminectomy at a point several segments above the level of the affected posterior nerve root Here the pain conducting fibres have decussated, so the tract is divided on the side opposite to that on which the pain is felt When bilateral section is done one side should be cut at least two spinal segments higher than the other The relief afforded by this operation is immediate *Bladder* function may be disturbed and retention of urine result This is transient usually though apt to be more persistent after bilateral section

J S R

CHAPTER VIII

PERIPHERAL NERVE INJURIES

INJURIES of the peripheral nerves are relatively uncommon in civil accidents They are common in war wounds and the experience gained in the last two European wars forms the basis of present-day treatment

When nerves are crushed within their neurilemma sheaths it has been found that regeneration and ultimate recovery of function are often satisfactory When nerves suffer anatomical division recovery (even after accurate suture) is usually poor save with the radial peroneal, and facial nerves The majority of nerve lesions therefore are followed by permanent disability varying in degree The disability may be trivial and require no further treatment Disability due to paralysis of important groups of muscles can sometimes be minimised by the use of special appliances or by such procedures as tendon transplantation or arthrodesis of flail joints Disability due to sensory loss in the hand or foot is always serious and loss of pain sensation in the sole of the foot may lead to intractable ulceration which necessitates amputation of the limb

The diagnosis of nerve injury can usually be made with precision by considering which areas are anaesthetic and which muscles are paralysed. It is to be remembered that a nerve lesion is readily overlooked, and it is therefore important to test nerve function before dealing with any incised wound. Especially is this so in the region of the wrist where a small wound may appear trivial and a large one may urgently demand attention for bleeding vessels and cut tendons. Diagnosis may occasionally be difficult when hysterical manifestations are added to the manifestations of actual nerve injury This combination is met with especially in wounded conscripts and it may be impossible to assess the functional element without special electrical tests (p 155)

An accurate case record is of special importance after nerve injuries for it shows when the initial treatment, conservative or operative has ceased to yield improvement and not only indicates the need for further treatment but is a guide to what form such treatment should take It is therefore highly desirable that the record should be complete from the date of injury and the general surgeon should be prepared to carry out the necessary tests Routine clinical examination is made at monthly intervals The area of anaesthesia is mapped out afresh and recorded Each muscle group is tested systematically for returning function and where function is present the power of contrac

tion is estimated The examiner must be on his guard against trick movements carried out by non paralysed muscles The electrical responses of the muscle groups may also be tested if this is feasible, but the observation is of less value than careful clinical examination

Electrical Stimulation—Electrical stimulation is used as a diagnostic measure to estimate the extent of paralysis as a method of treatment to maintain the tone of paralysed muscles, and as an adjuvant at operation to identify and determine the function of exposed nerves

As a diagnostic measure electrical stimulation has a certain limited usefulness. The classical *reaction of degeneration* first appears about a fortnight after a complete nerve lesion The reaction is tested by comparing the responses to galvanic and faradic stimuli through electrodes applied to the skin over the muscle Galvanic current normally stimulates both the nerves and the muscle fibres Faradic (induced) current owing to the rapidity of its intensity changes, stimulates only the nerves (and their end plates) In nerve lesions when the process of degeneration has reached the end plates faradic current ceases to evoke contraction while with galvanic current since the stimulus must pass from fibre to fibre within the muscle the contraction is slow heaving and prolonged The reaction of degeneration is of use in differentiating between physical and hysterical paralysis Following a nerve lesion the return of faradic excitability indicates nerve regeneration. The reaction is of all-or none type and gives no evidence of a partial nerve lesion or of incomplete regeneration

During treatment it is often desirable to stimulate denervated muscle with the object of minimising atrophy for this purpose galvanic currents are alone of service

During operation it is often desirable to stimulate nerve trunks either to identify nerves whose courses are distorted by fibrous tissue or to determine if exposed trunks are conducting For this purpose a condenser discharge apparatus is convenient because the intensity of the discharge can be controlled by altering the capacity of the condenser and the duration of the discharge can be controlled by altering the resistance of the circuit

DEGREES OF NERVE INJURY

Contusion results from minor violence such as a blow It is the lesion typically present in crutch palsy due to pressure on the radial nerve in the axilla The loss of motor and sensory function may from the first be incomplete and signs of recovery become evident within a few days No special treatment is necessary beyond temporary splinting to prevent stretching of the paretic muscles

Crushing and *traction lesions* (without anatomical division) result from greater violence and lead to degeneration of the axons distal to the site of injury Crushing of the radial nerve is a typical complication of fracture of the mid-shaft of the humerus Traction

trunk adequate treatment can be obtained only in a hospital which makes special provision for the treatment of nerve injuries

OPERATIONS ON NERVES

Primary suture of a divided nerve is carried out when the wound is expected to heal by first intention It is rarely feasible in war wounds which are often grossly contaminated In civil accidents contamination may be minimal especially when the wound is inflicted by a fragment of glass and primary suture with excision and closure of the wound can safely be carried out within the first eight hours or even longer in selected cases

The nerve is exposed and picked up by its fibrous sheath the utmost gentleness being observed to avoid further injury If any strand of the nerve has escaped division it must on no account be torn or cut where the division is already complete the traumatised nerve-ends are sliced off squarely with a fresh knife Repair is effected by approximating fibrous sheath to fibrous sheath by a few interrupted sutures of the finest available silk (Catgut is to be avoided because it induces an inflammatory reaction and leads to scar formation) The approximation must be accurate without rotation of the nerve trunk, and no suture should penetrate nerve tissue It was formerly taught that the sutured portion of the nerve should be implanted in fat or surrounded by Cargile membrane but this is now known to increase fibrosis and has been abandoned

Secondary suture is carried out in cases where primary suture has not been feasible Operation is postponed not only till the initial wound is soundly healed but till there is reasonable confidence that operation will not light up a latent infection The interval which should be allowed to elapse after complete healing varies as a rough guide the minimum after a mild superficial infection should be six weeks after frank but localised suppuration six months and after a spreading infection a year A short course of vigorous massage provides a useful test if it provokes no recrudescence of infection operation can safely be undertaken Delay for a few months does not jeopardise the chances of a successful result

An incision of generous length is made over the line of the nerve which is exposed above and below the lesion and traced towards it The dissection is often difficult and tedious for the nerve is embedded in scar tissue and its course is distorted When the nerve has been isolated the end bulbs are removed and further successive slices are cut till intraneural fibrosis is no longer evident till the sheath can be freely moved to and fro over the nerve bundle and till in the case of the proximal stump the normal fasciculated appearance is encountered The technical difficulty now is to unite the nerve-ends without tension for there may have been considerable loss of nerve tissue A gap of as much as 2 or 3 in. can be made good by freely mobilising the nerve above and below the lesion by stripping up the muscular branches from the nerve trunk and by immobilising joints for a week or two in the most advantageous position In the case of the ulnar nerve a

untreated or to lack of co-operation by the mother Even in the less satisfactory cases such a variety of trick movements is acquired that the functional result is good Later operations to stabilise joints or to transplant tendons are almost never called for

Plexus Injuries in Later Life.—These injuries are usually due to traction lesions in major civil accidents and to penetrating wounds in warfare The lesion produced is usually a combination of actual division of some of the nerves together with traction lesions of others Conservative treatment must be relied on almost to the exclusion of operation in the hope that those fibres which have escaped division will regenerate and yield a limb which, though functionally imperfect is yet useful

Operation in expert hands has undoubtedly yielded isolated successes Generally however it is found that exploration reveals a lesion which is irreparable that repair when feasible is an operation of extreme technical difficulty and that suture when achieved is rarely followed by more than partial recovery in a few muscle groups Operation therefore should be left to the surgeon with special experience of these injuries

Conservative treatment demands much time and prolonged care The limb must be splinted to prevent stretching of the paralysed muscles and the splint if sufficiently light to avoid being irksome requires repeated adjustment The muscles and joints require daily attention by a skilled physiotherapist The morale of the patient must be maintained by suitable occupational therapy and amusement This programme can rarely be fulfilled in a general hospital and no effort should be spared to transfer the patient to a hospital reserved for the treatment of nerve injuries

Simple treatment must however be applied from the first This can be limited to splinting the limb and taking care to prevent joint stiffness An improvised splint is conveniently made of Cramer wire and plaster of Paris The position required is the same as for treatment of obstetrical palsy (p 150) In addition the shoulder must be prevented from drooping lest the plexus be stretched and the splint should therefore be prolonged down the trunk to take a bearing on the pelvis The arm should be laterally rotated and the forearm supinated In no circumstances should rigid splinting be prolonged beyond the metacarpal heads, for if the small joints of the fingers are immobilised they rapidly become frozen —in this particular the splinting appropriate for adults and infants must be sharply differentiated Stiffness of the finger joints is further minimised by encouraging the patient to keep moving them with the sound hand Once daily the arm should be taken out of the splint so that all the joints may gently be put through their full range of movement care being taken never to allow the weight of the arm to depress the shoulder and stretch the plexus Massage and electrical stimulation can safely be omitted at this stage Finally periodic examination should be made and records kept (p 154) It should be emphasised that the treatment outlined is to be regarded as first aid and not as a substitute for skilled attention in a special hospital

Axillary Nerve.—The axillary nerve suffers crushing in a small

proportion of dislocations and fracture-dislocations of the shoulder Paralysis affects chiefly the deltoid Relaxation of this muscle is maintained by keeping the arm in an abduction splint Massage and electrical stimulation are carried out Complete recovery is to be expected in three to four months.

Anatomical section of the nerve is rare and suture is considered impracticable Permanent paralysis of the deltoid can be compensated by arthrodesing the shoulder joint, when a useful degree of movement of the arm is conferred by movements of the *scapula*

Radial Nerve—Lesions of the radial (musculospiral) nerve amply

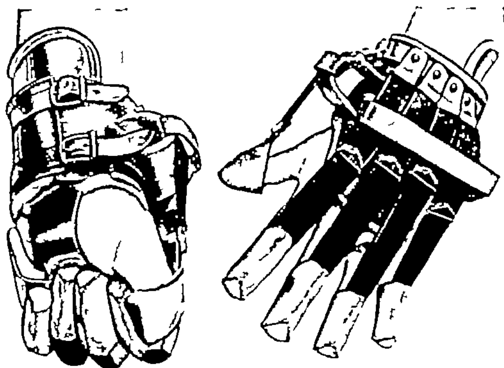


Fig 61

Oxford splint for radial palsy Leather thimbles attached by elastic to a dorsal bridge extend the fingers yet allow active flexion. (*After Highet, by courtesy of the "Lancet."*)

repay the care taken in their treatment, for the proportion of successful results is higher than with any other important nerve trunk. The nerve is especially liable to damage at two levels near the axilla and near the middle of the upper arm.

Near the axilla the nerve is sometimes contused or crushed but is rarely divided The nerve may be traumatised against the medial aspect of the humerus by the pressure of a crutch or when a drunkard falls asleep with the *arm dangling over the back of a chair* The nerve is occasionally stretched in shoulder dislocations In crutch palsy the lesion may be no more than contusion, and recovery may therefore be prompt when the use of a crutch is forbidden In the other types of injury the nerve is usually crushed and degenerates distal to the site of trauma Full recovery however is to be expected within six months if conservative treatment is thoroughly carried out Wrist-

drop is prevented by bandaging the forearm and hand to a cock up splint This can readily be made by applying a dorsal plaster slab from below the elbow to the metacarpal heads The patient is encouraged to keep straightening out the fingers with the other hand to prevent stiffness of the small joints If this precaution is neglected stiffness develops very rapidly and once established is difficult to treat Massage and galvanic stimulation are generally unnecessary and it is preferable that the patient should return to work if possible

If this is not possible exercises should be prescribed to prevent simple disuse atrophy of the limb and the shoulder should repeatedly be put through its full range of movement

The commonest site of nerve injury is the middle of the upper arm where the nerve lies close to the back of the humerus and is prone to injury when the shaft is fractured Any type of nerve lesion may be sustained but crushing is very much commoner than either contusion or division Indeed anatomical division of the nerve is rare except when the fracture is due to a gunshot wound The programme of treatment already suggested is therefore carried out as fully as the need for immobilising the bone fragments will allow A contused nerve recovers function within a few days whereas after crushing regeneration requires a few months Lack of any sign of recovery within six months indicates that the nerve has almost certainly suffered division the nerve should then be exposed and sutured In most cases a good result can be expected within a further six to nine months This outline of treatment is modified when the fracture is compound for the nerve can readily be inspected during the toilet of the wound and suture carried out either immediately or as soon as the wound is soundly healed

The most difficult problems in treatment arise when the nerve is divided in extensive wounds of the back of the arm especially in war wounds which are grossly contaminated Secondary suture is attempted (p 157) With irreparable lesions and when suture has proved unsuccessful disability is mainly due to permanent wrist-drop This greatly reduces grasping power and interferes with the general utility of the hand In suitable cases much benefit is obtained by transplanting the pronator teres into the radial extensors the flexor carpi radialis into the extensors of the thumb and the flexor carpi ulnaris into the common extensors of the fingers After a period of re-education the transplanted flexors serve as useful substitutes for the paralysed extensors

Ulnar Nerve—Despite its long course lesions of the ulnar nerve are common only above the wrist and at the elbow The ulnar nerve supplies most of the intrinsic muscles of the hand and the disability following nerve section is mainly due to loss of finer co-ordinated movement

Incised wounds above the wrist are usually sustained by thrusting the hand through the glass panel of a door or window The ulnar nerve may be severed along with the median nerve and a variable number of the long flexor tendons It is important to establish whether or not a nerve lesion is present before proceeding with the toilet of

extending the wrist and fingers or better by stimulating the fl group electrically) This manœuvre releases also the ulnar nerve, a good degree of regeneration can be expected in most cases

By far the commonest lesion of the ulnar nerve is late u neuritis developing as a sequel to cubitus valgus deformity i usually the result of fracture of the lateral condyle of the hume The course of the nerve is thereby lengthened and the nerve is t matised against the medial epicondyle whenever the elbow is fle: A similar condition may result from undue mobility of the n allowing it to dislocate over the epicondyle Irritation of the n leads to numbness and tingling in its sensory distribution especi when the elbow is flexed and to impairment of power in the s muscles of the hand Transposition of the nerve to the front of elbow should be carried out without delay

Anterior Transposition of Ulnar Nerve.—This is the commo operation practised on peripheral nerves and alone accounts for m than half of all published cases

The patient is conveniently arranged on the table with the fle elbow directed upwards and the back of the hand resting on the ch A 6 in incision with its centre at the elbow is made over the cours the nerve which is most easily located as it lies behind the me epicondyle Proximal to this level the nerve is mobilised by divid the covering fascia as far as the medial intermuscular septum F division of the septum is an important step in the operation. N the nerve is mobilised distal to the epicondyle by separating the hume and ulnar heads of flexor carpi ulnaris Care must be taken at t *stage not to divide any of the muscular branches of the nerve* th can if necessary be mobilised by stripping them up from the ner trunk The freed ulnar nerve can now be transposed to the front the elbow where a bed is fashioned for it by incising obliquely acr the common flexor origin A few sutures in the muscle serve to reta the nerve in position

Median Nerve.—The median nerve like the ulnar is often divid *in incised wounds above the wrist* Rarely it may be contused even divided by grossly displaced bone fragments in fractures of t wrist or elbow In war wounds it may be divided at any level T nerve trunk is large and deeply placed and for this reason is oft incompletely severed

Sensory loss is the chief result of nerve section with impairme of the movements of the thumb A recent nerve lesion is readi overlooked unless paralysis of the thenar muscles is appreciated b palpation while the patient moves the thumb The diagnosis becom obvious with the passage of time for the thenar muscles waste an there are trophic disturbances of the digits. These trophic disturbanc are often severe *Atrophy is especially marked in the index* and th skin is smooth glossy and often ulcerated

The treatment of median nerve lesions is on the usual lines App sition of the nerve-ends is easy after incised wounds but a large defe requires extensive mobilisation of the nerve *combined with flexion o* the elbow and wrist An important detail of post-operative treatmen

is to maintain freedom of movement of the first metacarpal, for the thumb tends to lie along the border of the palm where it rapidly becomes rigid and useless

The prognosis after division of the nerve is always bad and partial recovery of sensation is all that can be hoped for Even this slight gain however renders suture worth undertaking for the disability with a complete lesion is severe Lack of precise tactile sensation in the important thumb and index together with lack of precision in thumb movements renders the hand clumsy, and the patient uses it as little as possible Trophic disturbances and the development of ulcers may add to the patient s distress Causalgia develops in a proportion of cases and it is important to note that causalgia may follow division or irritation of even the small branches in the hand or digits There is exquisite tenderness of the skin and the lightest touch evokes burn ing pain which tends to radiate up the arm

The treatment of causalgia is unsatisfactory The part should be protected by wearing a mitten or glove Neurolysis should be under taken if the nerve is implicated in scar tissue If the nerve has been partially divided the damaged segment may be resected and the nerve sutured Division of the sympathetic chain below the third thoracic ganglion with the object of increasing the blood supply of the arm has had a vogue but the beneficial result is often temporary It is said that the temptation to amputate the offending digit should be resisted for causalgia may affect the stump demanding successive amputations at higher levels Generally but not always the symptoms become less severe with the passage of time

Sciatic Nerve.—Traumatic lesions of the nerve trunk are rare in civil accidents but are not uncommon in war wounds

Division of the nerve paralyses all the muscles below the knee and the ankle is therefore unstable The hamstring muscles often escape, for the branches supplying them are given off at a high level There is anæsthesia below the knee save in the distribution of the saphenous branch of the femoral nerve which supplies the medial aspect of the leg and the medial aspect of the posterior half of the foot In particular there is anæsthesia of the sole of the foot and severe ulceration is a common sequel

In *incomplete lesions* of the nerve trunk the treatment is generally to carry out nerve suture Muscular paralysis is seldom a cause of great disability for the patient can stand and walk if the flail ankle is stabilised by a surgical boot with double side-irons and a toe-raising strap The distribution of anæsthesia on the other hand, is important Thus when the lateral popliteal component of the trunk is divided sensation in the sole is preserved and the prognosis is good When the medial popliteal component is divided the sole is anæsthetic and the prognosis is poor Pain sensation is not often regained following nerve suture severe and intractable ulceration commonly develops and sooner or later the patient generally demands amputation Causalgia is not uncommon with irritative lesions of the medial popliteal com ponent and in a proportion of cases amputation may be demanded for the relief of pain

In *complete lesions* of the sciatic nerve suture is often impracticable because a long segment of the nerve may have been lost. Even when *suture is practicable it is seldom worth attempting.* It commits the patient to a long convalescence complicated only too often by intractable ulceration and terminated by amputation. For this reason primary amputation should probably be carried out more often than *is at present customary.*

Lateral Popliteal (Common Peroneal) Nerve.—Lesions of this nerve are relatively common for as it passes round the neck of the fibula its course is *superficial.* *Sensory loss is of little consequence.* Paralysis of the anterior group of leg muscles causes drop-foot and *paralysis of the peronei renders the ankle unstable.*

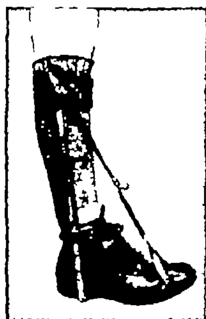


FIG. 63

Apparatus for drop-foot due to paralysis of common peroneal nerve. Lateral irons slotted into the heel are held in place by leather straps. A spring is incorporated in the toe-raising strap.

Contusion of the nerve results from direct violence. Thus it may result from a kick, especially in footballers, or complicate a fracture of the fibular neck. The commonest cause, however, is pressure from splints, plaster of Paris, orthopædic appliances and skin extension strapping; the nerve should therefore as a routine be guarded by padding. The treatment of an established case is to supply for use by day a surgical boot with double side-irons and a toe-raising strap and for use by night a plaster shell to maintain right-angled dorsiflexion and to prevent inversion. These should be worn till recovery is complete and are generally required for four to six *months.* *Massage* and electrical stimulation are unnecessary and the patient should be encouraged to return to work.

Section of the nerve in incised wounds is not common, but it is *noteworthy that suture yields a high proportion of successful results.* Severe traction lesions are much more common and occur as complications of dislocations and fracture-dislocations of the knee. These traction lesions are usually irreparable, for a long segment of the nerve undergoes fibrosis. In assessing the disability due to a permanent lesion it must be remembered that there are many occupations in which the wearing of a surgical boot is not a great inconvenience.

R. A. J.

CHAPTER IX

SURGERY OF THE AUTONOMIC NERVOUS SYSTEM

OPERATIONS for the interruption of autonomic nervous pathways have now a well-established place in the management of certain vascular and visceral disorders and in the relief of certain painful states In none of these conditions can pathological changes be demonstrated either in the ganglia or the fibres of the system and although originally much of the success attending autonomic denervation was attributed to the correction of a supposed sympathetic parasympathetic imbalance it is now increasingly obvious that the principal if not the only effect of such operations is to abolish the normal degree of autonomic control in the denervated part

Surgical attention is largely confined to the **sympathetic part of the system.** The efferent sympathetic fibres arising in the thoraco-lumbar parts of the spinal cord are distributed via the spinal nerves to the blood vessels of the limbs and to the sweat glands and via the visceral and sphincteric nerves and the visceral ganglia to the smooth muscle of the hollow viscera and possibly to the cells and glands of the viscera also

It is now clear that the efferent fibres of the sympathetic are accompanied by efferent fibres which are functionally if not anatomically separate Thus the stimuli of visceral abdominal pain reach the central nervous system by way of the splanchnic nerves and there is some evidence that the nerve fibres concerned in the production of causalgia following peripheral nerve injury may reach the spinal cord by sympathetic pathways

The **parasympathetic fibres** on the whole have an effect antagonistic to that of the sympathetic though the functional antagonism is in fact less marked than at one time supposed and has not proved a reliable basis for operation in visceral disorders The parasympathetic nerves are vasodilator and in the hollow organs they govern the contraction of non-sphincteric muscle and relaxation of the sphincters In addition they stimulate the secretion of various glands including the acid secreting glands of the stomach

Surgical interruption of parasympathetic fibres is practically confined to division of the vagi (vagotomy) in order to inhibit the initial or psychic flow of the gastric juice in peptic ulceration and to division of the parasympathetic fibres of the glosso-pharyngeal nerve which are distributed to the carotid sinus by carotid periarterial neurectomy Stimulation of these fibres may lead to slowing of the heart with syncope or convulsions and to widespread vasodilatation through

stimulation of the vasodilator centre in the medulla Such attacks can be prevented by *denervation of the sinus*

General Surgical Considerations

In present day surgical practice sympathectomy is chiefly used for the relief of vasoconstriction or to induce vasodilatation in vascular diseases associated with ischæmia to produce paralysis of sudomotor nerves in excessive sweating (hyperhidrosis) to obstruct the passage of painful stimuli in intractable visceral disease and in causalgia and

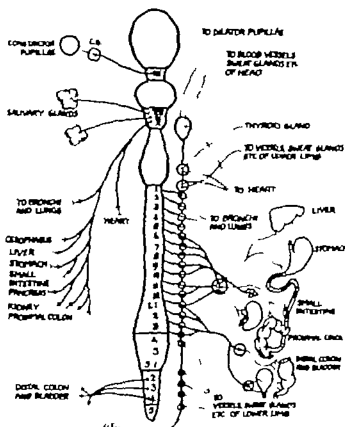


Fig 64
The autonomic nervous system.
Left—Parasympathetic. Right—Sympathetic.

in selected cases of hypertension It is now certain that in disturbances of visceral function —cardiospasm megacolon the neurogenic bladder and the achalasias of the urinary tract sympathectomy has no rational basis and it has for the most part been abandoned

Sympathetic denervation is attended by a large measure of success provided the patients are wisely chosen and the operation is planned and executed on anatomically accurate lines That occasionally the method fails to secure the intended effect or obtains it only transiently or to a limited degree is not an argument against its general validity for careful investigations and added knowledge have afforded an explanation for most of the unsuccessful or incomplete results Thus, limitations of surgical technique or anatomical variation in the system

may render complete denervation difficult, or again the tissues affected by the disease may be so altered by the pathological process that full recovery is out of the question—as in long standing Raynaud's disease Furthermore it is now known that regeneration of vaso constrictor nerves can also bring about a relapse or a recurrence, and progress of the original disease may in time annul the beneficial effects of sympathectomy while the presence of an intrinsic nerve mechanism as in the intestinal and bladder wall may limit the initial success of the denervation

Relief of Vasoconstriction

This effect may be sought in vasospastic diseases such as Raynaud's disease in obliterative vascular diseases such as thrombo-angiitis obliterans and arteriosclerosis and in conditions in which an increased blood supply is desired such as poliomyelitis with ulceration

Vasospastic Diseases.—In *Raynaud's disease* uncomplicated by secondary changes in the subcutaneous tissues or by structural changes in the digital vessels the attacks of intermittent spasm of the digital vessels are relieved but not abolished by sympathetic denervation of the limb The operation results in a permanent vasodilatation but the dilated vessels still contract in response to the stimulus of cold though now the constriction is not sufficiently great to arrest the circulation completely as in untreated Raynaud's disease The temperature of the limb is also raised and the improved blood supply promotes the better nutrition of the digital tissues In *erythromelalgia* the attacks of redness and burning pain usually of the feet are induced by warmth and not by cold like the Raynaud phenomenon Nevertheless there is evidence of vasomotor instability and sympathectomy has given striking results

It should be kept in mind in assessing a case or offering a prognosis that the secondary sclerotic changes which occur in the vascular subcutaneous and cutaneous tissues of long-established vasospastic disease militate against a satisfactory result The vessels are then too encompassed by fibrous tissue or are themselves too rigid to undergo full dilatation

Obliterative Vascular Diseases.—Here the surgical problem is quite different The vessels are occluded partly by thickening of their walls partly by thrombi which form on the diseased areas The degree of ischæmia developing depends on the site of the obstruction and on the availability of collateral channels The diseased and occluded arterial segment may act as a focus of irritation which causes reflex constriction in the remainder of the arterial tree but even when such spasm is absent division of the vasomotor nerves may reduce ischæmia by causing permanent widening of the collateral channels with consequent increase in the vascular supply to the distal structures

Sympathetic denervation should only be used with great discrimination in organic vascular diseases The indications should be clear cut and the probable effect carefully determined by the employment of the appropriate tests (see p 74)

The principal conditions in which the value of sympathectomy may have to be weighed are thrombo-angiitis obliterans (Buerger's disease) *and arteriosclerosis* The evidences of ischæmia are common to both intermittent claudication may result from muscle ischæmia and resting pain colour changes or gangrene from reduction in the blood supply of the skin and subcutaneous tissues Claudication alone usually betokens a high vascular occlusion (femoral or popliteal trunk) with a sufficient supply to the other tissues The effect of sympathectomy is not clear it is sometimes asserted that the relief of constrictor tone may deflect blood from the muscles into *the dilated cutaneous vessels* since the muscular arterioles have no sympathetic vasoconstrictor nerves This is wrong the operation is not followed by any relative increase in muscle ischæmia and more severe claudication in fact there are occasional excellent results particularly in those cases in which the arterial block is a high one Lower level occlusions near the origins of the muscular branches are less likely to be influenced by sympathetic ablation and since the exact site of the block can be demonstrated by arteriography *it may be possible to determine the type of case which has a* good chance of improvement

Resting pain colour changes and peripheral gangrene without claudication generally indicate *low level* vascular obstructions In such cases sympathectomy may lead to great improvement rest pain may be abolished colour restored and the area of gangrene so reduced that minor amputations may suffice

When gangrene or its precursors are associated with claudication it may be taken that there is considerable narrowing of the arterial tree over a wide extent in the management of such cases sympathectomy has no place

It is obvious that sympathetic operations must be preceded by scrupulous clinical and laboratory examination in specially equipped centres In general it may be stated that the indications for operation in arteriosclerosis are rare the patient is usually elderly and the extent of the sclerosis in the vascular bed precludes the development of collateral circulation In Buerger's disease on the other hand sympathectomy may abolish claudication in suitably selected subjects, it may delay or limit amputation and relieve the rest pain of threatening or established gangrene

Sudden Arterial Occlusion—In embolic vascular obstruction and after contusion or ligation of an arterial trunk the survival and the *nutrition of the distal parts depend on the* rapid opening up of a good collateral circulation This is retarded by the reflex vasoconstriction initiated by the sympathetic nerve fibres in the occluded or damaged segment Excision of the affected segment *may* diminish this vasoconstriction but sympathectomy may be necessary in addition to ensure the maximal effect Even when gangrene is averted by arterial anastomosis for example it is *wise to ensure that all additional* channels are at their maximal degree of dilatation and sympathectomy is especially necessary in wounds which may be supposed to have caused direct destruction of a proportion of the possible col

laterals In the last event the blood supply without release of vaso constrictor tone may not be sufficiently generous to ensure the future nutrition of the limb when activity is resumed This is especially so in the lower limb and after femoral or popliteal ligation permanent sympathectomy is a wise supplement In other vessels temporary interruption by injection of the appropriate ganglia may be satisfactory

Conditions in which an Improved Blood Supply is Desired—Sympathectomy has been carried out with varying success in a miscellaneous group of diseases in which the blood supply is inadequate but the vessels neither spastically contracted nor organically narrowed The operation leads to permanent vasodilatation and to the delivery of the maximum amount of blood to the affected parts

Poliomyelitis—The cold blue ulcerated limb of poliomyelitis may be improved by sympathectomy if the paralysis is not too extensive

Erythrocyanosis—In this disease there is a reddish purple discoloration of the lower half of the legs almost always in women The temperature of the skin is below normal and there is induration of the subcutaneous tissues Nodular swellings may appear and break down to form indolent ulcers a stage which was formerly known as Bazin s disease It has been suggested that in such cases defective venous return and the vasoconstricting action of cold combine to cause local tissue injury (Telford) On this basis sympathectomy has been advocated and has given striking results in the more extensive cases As a rule however the disablement caused by erythrocyanosis is not sufficiently serious to justify elaborate operative treatment sympathectomy should be reserved for the nodular and ulcerative stages

Ulcerative Lesions of the Face—The healing of indolent ulcerative conditions of the face such as may follow operation for trigeminal neuralgia has been hastened by removal of the superior cervical ganglion and stellate ganglionectomy carried out at the time of trigeminal section by causing Horner s syndrome may prevent some of the eye effects of oculo-motor anaesthesia

Relief of Visceral Pain.—Sympathectomy for the relief of pain has been most successfully practised in angina pectoris in intractable dysmenorrhoea in pain of renal origin and in painful lesions of the pancreas

Angina Pectoris.—Afferent nerves from the heart and coronary vessels pass from the cardiac plexus by the superior middle and inferior cardiac nerves to the superior middle and inferior (stellate) cervical ganglia and by additional accessory nerves which run across the posterior mediastinum to the upper four thoracic ganglia The fibres joining the cervical ganglia then pass downwards in the sympathetic trunk to the upper thoracic ganglia also and all the cardiac afferents finally reach the spinal cord via the white rami which connect the sympathetic trunk with the upper four thoracic spinal nerves

Complete interruption of these afferent pathways abolishes the pain of anginal and coronary disease This is held by many to be unjustifiable in so far as it removes the danger signal which warns

CHAPTER X

DISEASES OF BONES

ACUTE OSTEOMYELITIS

ACUTE infections of bone and its related tissues may result from the contamination of a compound fracture or from extension of an inflammatory process in an adjacent joint The most common and the most important variety however is that which is conveyed by the blood stream—*acute hæmatogenous osteomyelitis*

Acute blood borne osteomyelitis is primarily a systemic infection followed by a local lesion in the bone and for the most part the infecting organisms are sensitive to penicillin The large majority (80 per cent) of the cases are staphylococcal in origin and occur in the first two decades of life Streptococcal infection is the next most common while rare varieties may be due to the pneumococcus and the typhoid bacillus

Acute osteomyelitis is always a serious matter but the introduction of penicillin has profoundly changed the picture For some years past the tendency had been to adopt an increasingly conservative attitude to a disease once regarded as an urgent operative emergency The results of penicillin treatment have served to emphasise the wisdom of this policy and a situation has now been reached when it is true to say that many cases of osteomyelitis can be cured without active surgical intervention

The management of the individual case comprises the treatment of the general illness and the care of the local lesion The relative importance of each varies

THE GENERAL INFECTION

The septicæmia may be so overwhelming that it quite overshadows the bone focus which never becomes established or significant In this type penicillin therapy begun early is life-saving in all except the very fulminating infections The response to penicillin is neither immediate nor dramatic There is usually an obvious improvement in the general condition within 24 hours but fever continues for several days and it may be some days before the blood culture becomes negative Leucocytosis is often present for some weeks

THE BONE FOCUS

In the majority of cases the bone focus is the prominent feature of the disease though the systemic effects are usually well marked Here penicillin will not only control the blood infection but will sterilise the bone focus provided it can gain access to the infected

tissues The process of sterilisation covers a period of 14 21 days, and treatment must therefore be prolonged and regular Pain is relieved in the first 24 hours but the local metaphyseal swelling does not disappear for 5 6 days Swelling persisting for longer than this should raise the suspicion of a subperiosteal abscess

If treatment is begun before thrombosis occurs or before sub periosteal extension takes place the bony tissues may be sterilised without obvious sequestrum formation such destruction as does occur is cellular rather than massive and repair is apparently effected with a minimum of disturbance Radiologically the original focus eventually shows as an area of absorption and for several weeks there may be progressive decalcification of the metaphysis which is succeeded by recalcification and repair without deformity This phase is of considerable clinical importance, for though the infection is cured and the child feels and looks well yet activity has to be rigidly curbed until the architecture of the bone is fully restored

The occurrence of a subperiosteal abscess is not uncommon and must always be watched for it generally means that penicillin has not been started in time to prevent appreciable damage to the bone Once an abscess has formed penicillin will never sterilise it and it is necessary to evacuate it by aspiration or incision Sequestrum formation should not occur to any prominent extent unless treatment is long delayed, or inadequate or stopped too soon

Management of a Typical Case

Preliminary Investigations—A thorough clinical examination must be conducted, and metastatic foci sought for The condition of the related joint should be observed and the presence or absence of a subperiosteal abscess noted. A blood culture should be carried out in fully 50 per cent of cases a positive result will be obtained and information as to the degree of penicillin sensitivity of the organisms will be forthcoming

Treatment—This should not await the result of blood culture but should be begun as soon as possible

Penicillin Administration—The drug may be given by repeated intramuscular injection or by continuous intramuscular drip It must be continued for 28 days in order to ensure complete sterilisation of the bone The dose is not standardised, and may be varied with the age of the patient and the severity of the infection In fulminating cases 250 000 units four hourly after a massive initial dose (500 000 1 000 000 units) is reasonable In the average case an initial dose of 250 000 units is followed by 100 000 units four hourly until the tem perature settles and thereafter a daily injection of 300 000 units of distaquin is continued until the end of the course

There is no advantage in introducing the penicillin directly into the bone focus the drug has direct access from the blood stream and the introduction of local needles or tubes carries some risk of introducing infection with gram negative organisms Local administration should be reserved for cases complicated by secondary arthritis

Sulphatherapy.—There is some evidence that the simultaneous exhibition of penicillin and the sulpha drugs increases the efficacy of both As a rule however penicillin will be able to deal with most bone infections unaided and sulphathiazole should be reserved for cases which prove penicillin resistant

Immobilisation.—From the start of the treatment the limb should be rested on a suitable splint or in a plaster shell A complete plaster cast should be avoided in the early stages when a close watch has to be kept for the formation of abscesses, in the leg at this time a Thomas' knee splint is ideal in the arm a posterior plaster slab is adequate When the risk of abscesses is past a complete plaster may be used and immobilisation continued until there is radiological evidence of recalcification

INDICATIONS FOR SURGICAL INTERVENTION

The indications for operation in acute osteomyelitis are —

(*a*) Subperiosteal abscess
(*b*) Sequestrum formation

Subperiosteal Abscess.—This should be evacuated by incision and the temptation to drill the bone should be resisted The cavity may be dusted with a penicillin-sulphathiazole powder and the wound closed Aspiration is more difficult and apt to be less complete formal incision is preferable

Sequestrum Formation.—The formation of obvious sequestra *generally implies that treatment has been begun late or been stopped* prematurely they should be removed with the minimum of disturbance of the surrounding tissues and if penicillin therapy has been *previously stopped the operation should be preceded by 24 hours* intensive treatment

Acute Arthritis as a Complication of Osteomyelitis.—Infection in *the nearby joint is the most common local complication of osteomyelitis* and metastatic arthritis may occur in any of the other joints Primary drainage of such infections carries a high mortality and should be *avoided at all costs Repeated aspiration and replacement* of the fluid by 30 000 units of penicillin in 3 c c of saline together with immobilisation should be given a thorough trial it will be found that *in the majority of cases the arthritis subsides* under such a régime In the hip joint where repeated aspiration is difficult the penicillin may be administered locally through a sternal puncture needle *introduced into the metaphysis from* immediately below the great trochanter The solution percolates from the bone focus into the joint cavity

CHRONIC OSTEOMYELITIS

Chronic osteomyelitis may be a sequel of acute hæmatogenous osteomyelitis or the result of direct infection in open fractures The persistent infection may manifest itself by recurring attacks of swelling pain and redness with or without suppuration or there may

be a persistently discharging sinus or sinuses subject to repeated inflammatory flares

The most common causes of both lesions is the presence of undischarged sequestra or the persistence in the bone of a cavity filled with chronically inflamed granulation tissue The general adoption of penicillin therapy in the acute infections will greatly diminish the incidence of the chronic and recurring lesions but for many years to come the disease will continue to give considerable trouble especially in those who sustained gunshot wounds of the long bones



FIG 65

Chronic osteomyelitis following a gross compound fracture. A sequestrum is seen lying in a cavity in the tibia.

Penicillin is powerless to eradicate chronic infections in bone since the solution is unable to gain access to organisms imprisoned in avascular sequestra and dense bloodless inflammatory tissue Nevertheless it may suffice to keep minor and infrequent flares under control and the drug will prevent metastases and control soft tissue infections following operations for the removal of sequestra or the obliteration of bone cavities Such operations should be performed only after a preliminary 3-day course of systemic penicillin and they should be followed by a post-operative course of high dosage In late recurrent osteomyelitis with chronically discharging sinuses advantages of amputation should be considered, especially if signs of amyloid disease or renal damage are *present* It is a mistake—economic and otherwise—to postpone this step too long especially if the disease is extensive if the recurrences are frequent if there is

deformity or stiffness of the nearby joints and if albuminuria is present

Operation in Cases of Chronic Osteomyelitis—The objects of operation are to remove any sequestrum to obliterate the cavity and remove all dead bone and granulation tissue if possible In favourable sites such as the fibula the whole affected part of the bone may be removed

Access may be gained through the old incision but if another route offers a prospect of better drainage or of a more direct approach to the cavity it should be selected The bone is exposed with the minimum of soft tissue dissection the involucrum is chipped away over the whole extent of the sequestrum which is then removed along with the granulation tissue lining the cavity If the walls of the cavity are overhanging saucerisation should be effected by removal of enough bone to convert the cavity into a funnel or trough with gently sloping sides

Finally the wound should be liberally dusted with penicillin sulphathiazole powder and the skin sutured A narrow rubber tube—or a series of them—may be introduced before stitching for the subsequent local instillation of penicillin but if the method is employed to secure a high local concentration great care has to be taken to avoid secondary infection with penicillin resistant organisms

BRODIE'S ABSCESS

This very localised lesion is due to infection by attenuated organisms There is a small centrally placed abscess cavity most commonly at the upper or lower end of the tibia or the lower end of the radius it contains pus which is more often than not sterile and occasionally a small sequestrum The bone surrounding the focus is often markedly sclerosed and possibly on this account or because of its deep situation the lesion may be very painful

Treatment consists of removing the sequestrum and chiselling away the sclerosed abscess wall to leave a shallow depression in the bone The wound can be completely closed if the operation is preceded and followed by a course of systemic penicillin therapy

DEVELOPMENTAL DISEASES OF BONE

A considerable number of developmental or congenital bone diseases are now differentiated In most of them such as achondroplasia and chondro-osteodystrophy and the various types of giantism and dwarfism, surgery has little or nothing to offer in the way of cure or amelioration in others however correction improvement or disguise of the deformity is often possible This is unfortunately forgotten or ignored it should be borne in mind that even a small correction seemingly insignificant or trivial to the medical attendant may afford the cripple considerable happiness and lessen the heavy burden he has to bear

DYSCHONDROPLASIA

Dyschondroplasia affects those bones which are formed in cartilage, at the epiphysial lines the cartilage proliferates normally but the normal processes of degeneration calcification and ossification do not occur Exuberant masses of cartilage persist and form prominent irregularities which are most characteristically observed in the multiple enchondromata of the short long bones of the hands and feet

Surgical attention is most often sought in connection with the hand deformities which are ugly and distressing There should be no hesitation in performing curettage at multiple sittings until a semblance of normality is restored

MULTIPLE EXOSTOSES (METAPHYSIAL ACLASIS)

In this disease bony outgrowths develop in the neighbourhood of the limb joints as a consequence of the failure of the normal remodelling process which occurs at the metaphysial part of the long bones The exostoses may press on nerves or other nearby structures or interfere with the free movement of tendons but most commonly symptoms are due to an irritative effusion into the adventitious bursa which inevitably forms over the outgrowth

The disease has no effect on the general health and surgical treatment is only called for when local symptoms arise in relation to one or more of the exostoses In this event the offending growth is removed by the same method as for simple osteoma (p 180)

RICKETS

This constitutional disease of childhood is primarily within the province of the pædiatric physician and the dietitian but it has also important surgical implications in view of the many and crippling deformities it initiates

The essential pathological feature of rickets is the interruption of the normal processes of ossification at the growing parts of bones The bone laid down is soft irregularly formed, and poorly calcified and in consequence it is unable to withstand the stresses either of weight-bearing or of muscle pull.

The rachitic deformities of surgical importance which should be anticipated are kyphosis coxa vara bow leg (Fig 139) and knock knee (Fig 140)

The curative treatment of acute rickets is the provision of ample lime and a sufficiency of vitamin D by a diet rich in milk and supplemented by a vitamin D preparation Rest in bed is indicated to prevent deforming stresses on the spine or lower limbs The position in bed should be frequently changed, and massage employed to maintain the tone of the muscles If in the active stage deformity has occurred before treatment is begun complete correction may be obtained by moulding while the bones are still soft and pliable The affected bone is

manipulated at frequent sessions and in the intervals the limb is bandaged to a suitable well padded corrective splint

The deformities remaining after the disease is cured are corrected by fracture or by open operation according to the degree of deformity or the amount of disability The principles of correction are outlined below

Kyphosis —This takes the form of a rather acute curvature in the dorsolumbar segment of the spinal column In the active stage it disappears or improves greatly on recumbency In the late stage treatment is not indicated considerable improvement occurs as growth proceeds

Coxa vara —This is the most constant of the rachitic deformities. In the active stage simple recumbency generally restores the normal neck-shaft angle of the femur In old cases the deformity is permanent and when marked gives rise to a pronounced waddling gait and ulti mately painful osteo-arthritis develops In such circumstances correction of the coxa vara by osteotomy is indicated

Genu valgum —Rachitic knock knee is due to relative overgrowth of the medial condyle of the femur or less commonly of the tibia or to both combined Normally the axis of weight-bearing passes through the lateral part of the knee joint and this is increasingly the case if walking is permitted in the active stage of rickets The softened and yielding bone of the lateral side of the femoral metaphysis is thus compressed, whereas on the medial side the bony development is unhampered

Genu valgum may in turn give rise to secondary deformities, especially flat foot and a form of habitual displacement of the patella

In the active stage bandaging the leg to a straight lateral splint will promote correction after walking is resumed a knock knee iron should be worn if any deformity remains In late cases correction should be by supracondylar femoral osteotomy

Genu varum —If bow leg persists after the active stage of rickets correction may be obtained by creating a simple fracture at the site of maximum deformity (osteoclasis) provided the bones have not become too hard When re-ossification is well advanced linear osteotomy should be carried out

Osteitis Deformans (Paget s Disease)

Paget s osteitis is a simultaneous thickening and softening of the bones which leads to bending deformities and often to severe pain in late adult life The disease is progressive and since no means of staying its course are yet known, the fully established deformity—enlarged head bowed back and painful bowed legs—is often encountered in elderly persons

In a number of cases sarcoma develops in one or other of the affected bones but the most common complications are spontaneous fracture and osteo-arthritis

Treatment is palliative Support by means of splintage should be

provided if pain is pronounced and deformity is occurring. A spinal support or a caliper splint may thus be needed.

The pain of Paget's disease may prove very distressing. Characteristically it is not relieved by rest, elevation, warmth or external applications as most bone and joint lesions are; but in selected cases a linear osteotomy through the cortex at the site of greatest intensity may give complete relief. Alternatively multiple drilling of the cortex may be efficacious.

Parathyroid Osteodystrophy (Generalised Osteitis Fibrosa Cystica)

Generalised osteitis fibrosa cystica—a form of progressive decalcification of the skeleton—results from overactivity of the parathyroid gland. The calcium depletion is associated with fibrosis and cyst formation, and pain and extensive deformity of the softened bones may result. This syndrome is now regarded as being so characteristic that in its presence the diagnosis of a hyperplastic enlargement of one or more of the parathyroid bodies may be made with some certainty even in the absence of a palpable swelling in the neck. In addition to a very characteristic radiological picture there is an increase in the calcium of the circulating blood, the excess resulting from the skeletal decalcification. The essential part of the treatment of generalised fibrocystic disease is removal of the offending parathyroid tumour. This is usually followed by a gradual improvement in the condition of the bone; the cystic areas disappear and the lime content progressively increases until it is normal. When this stage is reached, deformities which are frankly disabling should be corrected by osteotomy.

Localised Cystic Disease (Simple Bone Cyst)

A solitary bone cyst may appear in one of the long bones during adolescence, the commonest sites being the upper end of the femur and the upper end of the humerus. It is located in the metaphysis and enlarges insidiously and painlessly until the wall is reduced to a film of bone barely perceptible on radiological examination. Pathological fracture is prone to occur and is sometimes the first and only indication of the lesion; it may be followed by spontaneous healing.

The most satisfactory method of treatment is to open the cyst, evacuate the brownish or blood-stained fluid it contains and curette the lining tissue. This alone generally leads to repair, but to hasten the process the cavity may be packed with bone chips or a massive bone graft inserted.

Lipoid Granulomatosis

In this disease the bones are the site of destructive granulomatous tumours consisting of proliferated reticulo-endothelial cells laden with lipoid. Such tumours may exhibit evidences of pressure on adjacent structures, and a very typical clinical picture—the Hand-Christian-Schüller syndrome—occurs when the skull is affected.

Exophthalmos caused by a deposit in the orbit is associated with diabetes insipidus from pressure on the pituitary stalk and with irregular defects in the bones of the cranial vault The level of the blood cholesterol is generally raised.

The aim of treatment is to cause fibrosis and regression of the tumours already present and to prevent, if possible the development of fresh deposits X ray therapy is highly successful in the first of these objects and under its influence not only do the swellings disappear but repair of the bony defects is effected It may also be necessary to control the diabetes insipidus of the Hand-Christian-Schüller syndrome by injections of pituitary extract

Post traumatic Osteodystrophy (Sudeck s Painful Atrophy)

Following joint injuries, a very painful syndrome consisting of acute osteoporosis vasomotor phenomena swelling, and stiffness may occur during the second or third week The mechanism of these changes is not known but a sympathetic reflex disturbance has been suggested as the most likely explanation

In mild cases rest in a splint and the application of heat lead to slow improvement The more serious cases often progress after many weeks of pain to complete ankylosis and it is important if the joint is to be immobilised that the position of optimum function be secured

Sympathetic denervation of the limb has been claimed to give good results notably by Leriche who employed periarterial sympathectomy In this country, the operation has been of doubtful value, and even more adequate sympathectomy (*e.g* stellate ganglionectomy) is very disappointing

Myositis Ossificans

The development of bone in the connective tissue of muscle is an important complication of injury in many situations notably in the quadriceps following blows on the front of the thigh and in the brachialis muscle following dislocation of the elbow The explanation is not clear but it is certain that forced movements and massage at too early a stage favour its development and spread. For this reason it is wise not only to insist on a proper period of immobilisation after serious joint injuries but to encourage the return of function by *active* movements rather than passive stretchings and massage

Myositis ossificans has a distinct tendency to undergo spontaneous reabsorption, and to begin with its treatment should be conservative It is of course both impossible and unnecessary to insist on absolute rest but the use of the part should be reduced to a minimum When the quadriceps is implicated games should be prohibited in the elbow active movements are allowed but passive movement is forbidden. Periodic radiological examination will show the progress of the disease If at the end of a reasonable period the new bone has become con solidated and is seriously limiting the activity of a joint excision of the mass may be carried out It cannot be too strongly emphasised that operation in the early stages is absolutely contraindicated the

trauma of operation serves only to bring about a recurrence often more gross than the primary lesion itself

BONE TUMOURS

Tumours of bone occur in infinite variety and the various types differ widely in their significance and their treatment Each case of bone tumour or suspected bone tumour therefore merits a very scrupulous investigation and it is wise to regard all cases as potentially serious until an accurate clinical and radiological survey has been completed

Investigation of a Case of Suspected Bone Tumour

Radiological examination is first carried out the plates should be taken in several planes so that the smallest imperfections of structure may be detected it is generally wise to take films of the corresponding part of the other limb for purposes of comparison The first films may clearly establish the simple nature of such growths as osteochondroma chondroma and the giant cell tumour If the radiographs indicate a malignant tumour the presence of metastatic growths or in tumours like myeloma the presence of multiple foci should be excluded by X raying the chest and the remainder of the skeleton In doubtful cases further investigation is necessary A Wassermann test will help to distinguish syphilitic osteitis which may resemble a tumour very closely

Examination of the blood may reveal a leucocytosis and suggest an infective origin for a doubtful radiological picture and the bone marrow removed by sternal puncture gives important evidence in cases of multiple myeloma In multiple tumours especially in childhood the possibility of lipoid granulomatosis has to be kept in mind estima tion of the blood-cholestrol may assist the diagnosis for it may be raised in this disease Estimation of the calcium and phosphorus content in the serum should be undertaken in all lesions of bone associated with multiple cystic defects The level of the alkaline phosphatase in the serum is raised in conditions associated with osteo-blastic activity such as osteitis deformans and some sarcomas A rise in the serum acid phosphatase—which is produced by the prostatic epithelium—may serve to distinguish prostatic metastases in bone from other skeletal lesions

Examination of the urine may show the presence of Bence-Jones protein, and suggest a diagnosis of multiple myeloma In some cases multiple metastatic deposits bear a close radiological resemblance to Paget s disease and the converse is also true The common primary sources of bone metastases should be carefully examined they are the prostate the kidney the breast the bronchi and the thyroid gland.

Biopsy—When the clinical, radiological and biochemical examina tions still leave the diagnosis in doubt biopsy is imperative The dangers often said to be associated with this are grossly exaggerated.

There is in fact no evidence that properly conducted biopsy has ever increased the gravity of the prognosis or harmfully influenced the patient's immediate condition

A tourniquet should be applied above the tumour after the growth is exposed one or more pieces are removed preferably by means of a cautery or diathermy knife and the raw surface is then cauterised with a 50 per cent solution of zinc chloride or with Zenker's solution If the pathological examination is to be an immediate one the wound is *closed and all instruments and towels* already used are discarded the part is freshly prepared and draped and instruments resterilised while the surgeon is awaiting the histologist's verdict

There is however little or no disadvantage in allowing a short interval to elapse between biopsy and operation rather the reverse *for bone pathology often is not* easy to interpret in the hurried environment of a rapid section biopsy

THE TREATMENT OF SIMPLE TUMOURS

Osteoma.—The *simple cancellous osteoma is an outgrowth* from the metaphysis of a long bone and occurs especially in the region of the knee Its principal effects are mechanical and removal is indicated when it interferes with the free movement of a joint or tendon or exercises harmful pressure on a nerve

Although largely bony the osteoma has a cap of cartilage on the deep surface of which the further growth of the tumour depends The preliminary dissection therefore must not damage this the osteoma is exposed with the cap intact and with its fibrous sheath unbroken The mass is then divided flush with the parent bone The raw surface *remaining after its removal is covered with Horsley's* carbolised beeswax or well hammered to diminish the risk of bony spur formation.

Chondroma.—The chondroma occurs in two forms at the ends of long bones and in certain flat bones notably the ilium and the scapula a lobulated mass of considerable size may project from the surface of the parent bone and displace and compress the neighbouring structures. Its effects like those of the osteoma are mechanical its stout capsule of fibrous tissue as a rule enables the tumour to be shelled out but occasionally the irregularity of the surface renders *its removal difficult*

A more common and characteristic type of chondroma occurs as a central tumour within the parent bone—an enchondroma The usual site is in the hands and feet and there may be considerable expansion of the bone and obvious deformity The tumour closely resembles the multiple *cartilaginous growths of dyschondroplasia* The *growth of a* central chondroma is usually slow but occasionally after a period of slow growth and few symptoms attention is sharply focused on it by sudden painful enlargement or by pathological fracture These effects taken in conjunction with the invariably atypical histological picture were generally held to indicate malignant degeneration and radical treatment was often adopted. The experience of the Registries of Bone Tumours seems to deny this possibility there are few authenticated cases of the development of *sarcomatous change in a simple*

chondroma of the hand bones so that amputation of a finger or resection of a metacarpal is rarely necessary

Curettage is adequate treatment The incision is made on the dorsal aspect of the bone and the attenuated cortex divided The tumour tissue is removed by means of a sharp spoon, the cavity should then be cauterised by zinc chloride or Zenker s solution and finally the walls are crushed inwards to obliterate the gap If the tumour is so extensive that its removal will leave too large a space to be easily obliterated or will seriously weaken the bone autogenous bone chips may be implanted to stimulate new bone formation

Benign Giant Cell Tumour—This is essentially a tumour of the epiphysis and therefore occurs or begins in young adult life The lesion is subcortical and destructive the cortex becomes thinned out to a fragile shell which is expanded by the growing tumour and is sometimes even perforated The commonest sites are the adjacent ends of the femur and the tibia and the lower end of the radius

In considering the treatment of the giant cell tumour it is well to bear in mind the marked tendency to local recurrence after curettage This is sometimes held to be due to incomplete operation but the tumour is believed by many to represent some disturbance in the normal process of osteoclasis following trauma and hæmorrhage in epiphysial bone and it is possible that the further trauma of operation initiates recurrence In some cases a malignant metastasising tumour with a closely allied or indistinguishable histological picture has been known to occur It is not clear whether this represents a malignant change in the benign giant cell tumour or whether it is a primarily malignant tumour with giant cells In any case the danger of malignancy is not great and there is no evidence that primary conservatively planned operations seriously increase the risk.

The choice of treatment in most cases lies between irradiation excision and curettage

Irradiation is the treatment of choice in the large majority of cases The response to irradiation is evident within five to six weeks and continues slowly for many months in successful cases complete healing with perfect recalcification takes place Irradiation should not be used after curettage it is liable to retard repair by its effect on the newly formed blood vessels of the reparative granulation tissue

Since it offers the most speedy prospect of cure excision is indicated in situations such as the head of the fibula or the lower end of the ulna where loss of the tumour bearing segment of bone is unlikely to interfere greatly with the function of the limb If the size and extent of the growth preclude other forms of treatment excision may also be used in certain sites where its disadvantages may to some extent be overcome by reconstructive procedures for example in the head of the humerus which may be replaced by transplanting the upper end of the fibula or in the talus when the foot may be stabilised by Whitman s reconstructive operation

Curettage is reserved for tumours in which for any reason X ray therapy is contraindicated and it may have a use in very small growths The tumour is exposed through a suitable incision and

thoroughly curetted by means of a sharp spoon The wall of the cavity is cauterised by pure phenol or by Zenker's solution Bone chips may be introduced to facilitate healing though the value of this measure is doubtful and it may stimulate further osteoclasis and thus promote recurrence If the tumour is near to a joint care must be taken to prevent a pathological fracture and the part must be immobilised carefully until there is radiological evidence of healing

Amputation may have to be resorted to if there are repeated recurrences if resection leaves a flail limb or if serious sepsis develops at the site of operation

Benign Giant Cell Tumour with Pathological Fracture—A spontaneous fracture occurs in about 15 per cent of cases of giant cell tumour unlike the bone cyst however the tumour shows no capacity for spontaneous healing afterwards Treatment should consist of a preliminary period of two to three months immobilisation of the affected limb supplemented by deep X ray therapy If these measures are unsuccessful curettage resection or even amputation may have to be considered

The Treatment of Malignant Bone Tumours

The treatment of bone sarcoma is still unsatisfactory and disappointing and the number of cures by any of the available methods of treatment is tragically small Nevertheless there are encouraging signs of improvement in the picture including a better appreciation of the early X ray appearances and earlier diagnosis a more accurate knowledge of the types and of the natural history of bone growths together with advances in the apparatus technique and dosage of X ray therapy

The methods of treatment available are few—amputation resection and irradiation The selection of the method must be made after the type of the tumour and its extent have been determined (if necessary by biopsy) and after its prognosis has been carefully assessed. Unfortunately there is no general agreement as to the choice of treatment in the individual lesions the following rules offer such guidance as the present evidence appears to warrant

Osteogenic Sarcoma.—In the true osteogenic sarcoma there are no proven cures from X ray treatment bone like nerve being very radioresistant In fact the tumour may continue to enlarge in the course of the therapy Amputation has to be regarded as the method of choice therefore and it should be carried out as soon as the diagnosis is established Even in advanced cases removal of the limb is indicated as a palliative measure for the relief of intolerable pain

The employment of post-operative X ray treatment does not appear to influence the development of metastases in any way and should not be insisted upon Other methods of treatment which have enjoyed a spurious popularity—Coley's fluid for example—are valueless

Chondro-sarcoma.—This tumour whether occurring in the long bones or in flat bones such as the pelvis is also quite resistant to X ray

treatment The therapy may cause some calcification in the growth, but does nothing to arrest its progress Amputation should therefore be carried out wherever possible

Ewing's Tumour—Ewing's endothelioma of bone is on the contrary very markedly radio-sensitive and X ray treatment leads to rapid subsidence of the original growth to healing of pathological fractures and to considerable new bone formation The cure in most cases is not a permanent one though many years of useful life may result Metastatic growths appear eventually despite repeated courses of prophylactic irradiation Local recurrence is less common if repeated it forms the only indication for operation in this tumour and amputation should be carried out if the lesion is situated in one of the limb bones The results of primary surgical treatment do not compare favourably with those of X ray therapy which is in fact the method of choice Incomplete operations—curettage for example—should be avoided the most that is permissible as a prelude to irradiation is the removal of sufficient tissue for histological identification of the tumour

Reticulum Cell Sarcoma.—This tumour recently segregated from the Ewing group is composed of reticulum cells and a fine reticular stroma It is a destructive lesion of adults commonest in the femur tibia humerus and clavicle It begins in the medullary cavity and is very osteolytic but compared with the true Ewing's tumour it is relatively benign and shows a good response to irradiation which appears to be the treatment of choice

Plasmacytoma.—This primary tumour of bone occurs both in long bones and in flat bones such as the skull, pelvis sacrum and sternum The growth is composed entirely of plasma cells it completely destroys the affected part of the parent bone and pathological fracture is common

The plasmacytoma is fairly radio-sensitive and irradiation is the treatment of choice The prognosis is not good however and in most of the recorded cases of solitary plasmacytoma multiple myelomata have eventually developed. Operative treatment is contraindicated on this account

Multiple Myeloma.—The multiplicity and inaccessibility of the deposits of multiple myeloma rule out any possibility of surgical treatment The tumours vary greatly in their response to irradiation and the disease is generally fatal but X ray treatment should be employed as a palliative measure even in advanced cases since it relieves the distressing pain.

Fibro-sarcoma.—The fibro-sarcoma of the periosteum is a relatively well-differentiated sarcoma and as such is resistant to reasonable therapeutic doses of X rays Amputation is the treatment of choice

Amputation for Bone Sarcoma—The amputation for bone sarcoma should be planned with due regard to the later fitting of an artificial limb it should be placed at the nearest seat of election above the tumour provided that level of section is well clear of the growth. It is not necessary to disarticulate at the nearest joint the bone can be cut across with complete confidence since local recurrences are very rare Disarticulation of the limb should certainly be avoided unless the tumour is situated high up on the proximal bone of the limb

Resection of the tumour and the affected part of the bone is sometimes recommended this is not good surgical practice and even on purely æsthetic grounds the patient is better served by amputation and a well fitting prosthesis

In performing the amputation the only point of special importance is use of a tourniquet to prevent the possible discharge into the circulation of tumour cells set free by the operative manipulations

Secondary Malignant Tumours in Bone—Bone metastases are common in the late stages of carcinoma of the breast the bronchus the prostate and the thyroid and in hypernephroma The deposits may be found anywhere in the skeleton but the vertebral column the humerus the femur and the skull are the most frequent sites

Metastatic tumours are notable for the excruciating pain to which they give rise and since their effect on the bone is purely osteolytic pathological fracture is common

Treatment is only called for on account of pain and the most effective way of ensuring relief is by X ray therapy supplemented by rest or if there should be a pathological fracture by immobilisation

The *secondary hypernephroma* presents certain unusual features unlike the other metastatic growths it is more often than not single and on the whole is radio resistant to the usual therapeutic X ray dosages In several cases resection of the part of the bone involved with subsequent replacement by graft has been successful and combined with removal of the primary renal tumour has occasionally resulted in many years of apparently normal existence

J B

has resolved There is usually no advantage in giving a sulphonamide in addition to penicillin unless the response to the latter proves to be limited or absent

Local Measures—The joint should be aspirated as soon as possible and the fluid sent for bacteriological examination and for penicillin sensitivity tests After complete evacuation of the contents 30 000 units of penicillin in 3 c c of fluid are introduced into the cavity before the aspirating needle is withdrawn and the joint is then immobilised.

Aspiration and penicillin replacement should be repeated daily or at longer intervals as required The joint should not be allowed to become overdistended as this leads to softening and stretching of the capsular ligaments furthermore in the early stages of a joint infection the synovial effusion is itself highly bactericidal and phagocytic and it is an advantage to encourage its frequent replacement when it becomes effete

The local instillation of penicillin should also be continued for some days after the joint is sterilised a point which is easily determined if the aspirated fluid is submitted to routine bacteriological examination

Immobilisation—The inflamed joint must be adequately splinted In the case of the hip and the knee joints it is important also to employ gentle traction It not only helps to immobilise the joint but also ensures the separation of the articular surfaces The Thomas knee splint and the Jones hip frame are the most suitable appliances for this purpose and the joints should be splinted in the position of optimum function. Thus the knee joint should be slightly flexed and the hip joint slightly flexed and abducted the shoulder should be in right angled abduction the elbow flexed to just short of a right angle and the wrist dorsiflexed

Mobilisation of the Joint—Movement may be permitted at the joint a week or ten days after the infection has clinically subsided and the joint has become bacteriologically clean In the case of the lower limb joints weight bearing should not be allowed until the range of movement is well established and the muscle tone is restored

The Hip Joint—The hip joint offers certain practical difficulties in treatment aspiration is not easy and repeated aspiration may be impracticable especially as distension of the capsule becomes less obvious as the inflammation resolves It may even be necessary to abandon local instillation, and rely entirely on systemic penicillin therapy in this event the dosage should be doubled and 80 000 units given three hourly

Indications for Operative Treatment—Arthrotomy will rarely be required if a diagnosis of acute arthritis is made early and treatment is begun promptly Even when the joint is distended with frank pus when first examined the response to penicillin is usually striking and in all cases penicillin should be tried for 48 hours before resorting to operation Incision may be required if the infecting organism should prove penicillin resistant if the pus is too thick to aspirate or when the disease has progressed to involve the articular surfaces seriously

The joint is then opened by a suitable incision which should if possible allow dependent drainage If the synovial cavity contains

many recesses, as in the case of the knee, more than one incision should be used

The joint cavity is emptied, and then irrigated with warm saline a Higginson s syringe being a convenient means of introducing the fluid under pressure

The joint cartilage is now inspected If it retains its normal sheen and there is no ulceration a mobile joint is to be expected after the disease has healed The fibrous capsule may then be closed by one or two interrupted catgut sutures If the joint is superficial the wound in the overlying parts is simply left open but if deeply placed a rubber drain may be led down to the capsule or the wound may be lightly packed with vaseline gauze A liberal dressing is then applied and the limb splinted.

Immobilisation is continued until the wounds have healed and the articular thickening has subsided At this stage active movements are begun and physiotherapy employed to assist the return of function Passive movements however are absolutely contraindicated

If the cartilage is extensively destroyed a useful range of movement in the joint is not to be expected Even if complete ankylosis is avoided the amount of movement is likely to be so small and so painful that the patient will be better off with a firmly fused joint It is good practice in these cases to plan the treatment in such a way that sound ankylosis is encouraged. The joint should be laid open by wide incisions which give access to every possible recess and irrigation carried out until the returning fluid is clear The wounds are left open and a copious dressing of gauze and wool applied. The limb is then immobilised with the joint in the position of optimum function Traction should not be used since close approximation of the joint surfaces is desirable

Later a plaster cast should be applied and a long period of protection is necessary in order to avoid deformity before the ankylosis is sound A careful watch must also be kept for the occurrence of spontaneous dislocation which sometimes complicates the convalescence of suppurative arthritis of the hip and of the knee

Amputation in Acute Arthritis.—If a case of acute arthritis is penicillin-sensitive and properly treated from the beginning the question of amputation should never arise It may have to be considered however when the organisms are resistant and the adjacent bones are extensively involved In cases in which secondary infection has supervened and there are chronic discharging sinuses amputation may be the readiest means of ridding the patient of a great source of danger in view of the risk of waxy disease Long-established suppurative arthritis of the knee is sometimes complicated by the extension of the suppuration to the tissue planes of the thigh. Pus then spreads upwards around and between the muscle fibres and secondary abscesses occur at several sites In such cases the patient is generally very ill and frequently in no state to withstand repeated surgical operations under anaesthesia amputation may then offer the only chance of saving the patient s life or at least of avoiding prolonged and difficult convalescence

Acute Pneumococcal Arthritis

Acute pneumococcal arthritis occurs in association with some other pneumococcal lesion such as pneumonia It may arise during the course of the primary disease or in the convalescent period, and most commonly involves one of the larger joints especially the hip and the knee The pathological effects vary from a serous synovitis to a purulent arthritis involving all the components of the joint

The coexistence of the other pneumococcal lesions makes the prognosis in this type of joint infection serious Treatment initially should be on the lines already laid down Sulphapyridine should in addition be administered in full doses

Gonococcal Arthritis

Towards the end of the third week of an acute gonococcal urethritis, a serous serofibrinous or purulent arthritis of gonococcal origin may be encountered It is usually mono-articular and most frequently involves the knee

The management of gonococcal arthritis comprises close attention to the primary focus as well as the treatment of infected joints The local joint treatment should in the first instance be confined to aspiration and penicillin replacement If there is much destruction of the joint surfaces the surgeon will have to decide whether to attempt to restore some range of active movement or whether it is preferable to immobilise the joint in the position of optimum function and await a sound fibrous ankylosis If movement is sought a long course of physiotherapy is essential in some cases the induction of hyperthermia is followed by remarkable improvement in the joint condition.

CHRONIC ARTHRITIS

Chronic arthritis is as old as the beginning of history Nevertheless, its treatment is still far from satisfactory and the disease is a formidable drain on the economic resources of industry as well as the source of an incalculable amount of pain and unhappiness

If improvement in the lot of the chronic joint case is to be effected both patient and doctor must be assured that the disease is less hopeless than is commonly supposed, and to this end close co-operation between the physician and the orthopædic surgeon is essential if relief of pain, correction of deformity and economic rehabilitation are to be secured

Types of Chronic Joint Disease.—The simplest classification of chronic joint disease which has also the merit of long and common usage embraces three readily distinguished types—rheumatoid arthritis osteo-arthritis and chronic villous (menopausal) arthritis

Rheumatoid arthritis is essentially a polyarticular disease of the

lining of the joint with a marked tendency to ankylosis It occurs particularly in women and the patient usually looks anæmic and ill

Osteo-arthritis on the other hand is a degenerative lesion of the bony and cartilaginous structures of the joint It is usually mono articular and has no tendency towards ankylosis though there may be limitation of movement due to bony or cartilaginous outgrowths or to fibrous contracture of muscles

Chronic villous arthritis or monopausal arthritis has some of the features of each of the others It begins as a proliferative synovitis but has not the same tendency as rheumatoid arthritis to attack the articular surfaces, so that ankylosis is not to be expected In its late stages degenerative changes like those of osteo-arthritis occur in bones and cartilage probably because of the impaired nutrition of these structures consequent on the failure of the synovial membrane as a source of nourishment The disease most commonly affects one or both knees and occasionally the hips of women over middle age

Rheumatoid Arthritis

For the medical measures to be employed the reader should consult a textbook of medical treatment Surgical measures are aimed at preserving the function of the joints and avoiding deformity without interrupting the process of repair The tendency to deformity is a particularly strong one since the inflamed joints tend naturally to assume positions of greatest ease and these unfortunately are also positions of deformity The deformities most prone to occur are flexion of the hip flexion and subluxation of the knee adduction and medial rotation of the shoulder flexion of the elbow flexion of the wrist, flexion and ulnar deviation at the metacarpo phalangeal joints and in the foot flattening of the arches hallux valgus and claw toes

Treatment in the Acute Phase.—While the disease is active the affected joints must be put at rest in the optimum functional position of the joint any form of light easily removable splint may be used but plaster of Paris is particularly suitable since an accurate fit can be guaranteed. The fit is very important for the skin of the rheumatoid subject is particularly prone to the development of pressure sores

The rheumatoid joint must not be absolutely immobilised owing to the powerful tendency to ankylosis and a regular system of move ments must be adopted. Once each day the splints are taken off and the affected joints passively moved within the limits of the patient s tolerance which may however be increased by the use of an analgesic such as veganin. If these movements are followed next day by increased stiffness the range should be temporarily diminished

Physiotherapeutic measures such as radiant heat massage and faradism are all valuable in helping to promote an increase in the range of movement of the joints The radiant heat should be applied for ten to fifteen minutes daily longer periods may especially at the start be followed by swelling and pain and restriction of the joint movements Massage is employed for many reasons it improves

the nutrition of the skin and the muscles and it is soothing to the inflamed joints Faradism is used at the start of treatment to induce regular contractions of the articular muscles later the patient should be taught to contract her own muscles actively

Treatment in the Subacute Phase —When the active phase of the disease subsides as indicated by improvement in the general condition and by the return to normal of the sedimentation rate the patient is still kept in bed but active movements are encouraged and the splints left off for part of the day and finally used only during the night Simple exercises are begun and their scope gradually extended as muscular tone returns

When weight-bearing is at length contemplated it is well to remember that the joints are to a greater or less extent permanently marked by the disease in the lower limb therefore support may be necessary to permit the resumption of activity A metatarsal bar and a Whitman's valgus brace may greatly help the foot a firm crêpe bandage on the legs gives a sense of warmth and helps to prevent œdema if the knee is unstable a knee corset or a knee cage may restore a feeling of stability and prevent the minor traumata to which the unstable knee is always subject while a damaged hip may be spared by the use of a well fitting walking caliper Crutches should also be used to begin with and only discarded when the patient's confidence is restored and the condition of the joints warrants it

Even after the period of constant supervision is passed, regular attendance at a good physiotherapeutic centre should be insisted upon the patient is then periodically supervised and what is perhaps more important the joints are systematically exercised and re-educated

Treatment of the Deformities of Rheumatoid Arthritis —The correction of deformed rheumatoid joints must be approached with great circumspection In the subacute and chronic stages the use of forcible methods is very liable to be followed by a flare up in the articular inflammation, with serious consequences so far as the function of the joint is concerned

Cases of rheumatoid deformity fall into three groups—deformity associated with a potentially useful range of movement deformity associated with disorganisation and fibrous ankylosis and deformity associated with bony ankylosis

Deformity with Persisting Movement —In this class of case it must be the surgeon's aim to preserve the range of movement which is present and to increase its usefulness by improving the alignment of the joint It is important, therefore to employ only gentle and gradual methods and if at all possible active and passive movements should be carried out at intervals during the progress of the correction

Some system of traction represents the ideal method but though excellent and applicable in the lower limbs it cannot be easily arranged in the cases of deformities of the upper limb joints Even in the hip and knee joints extension may be insufficient if the shortened structures have become so fibrosed as to resist stretching It may be necessary therefore to supplement traction by operations designed to lengthen or divide the contracted tissues

Deformity associated with Fibrous Ankylosis—In this group of cases correction of deformity will not alone lead to increased function in the disorganised joint The object of treatment is to increase the useful ness of the limb as a whole and enable the patient to get the best service from the other joints if these possess satisfactory function For the most part this entails the provision of a sound ankylosis in the corrected position If the deformities are multiple however the patient may be better off with the joints left as they are This is especially so in the case of flexed hips and knees straightening of these joints with fixation in extension makes the woman bedridden unable either to walk or to sit whereas the flexion deformities may previously have enabled her to be wheeled about in a chair

On the other hand the possible advantages of operative procedures other than for the simple correction of deformity must be assessed it may for example be possible to restore mobility at certain of the joints by arthroplasty or some form of pseudarthrosis

In many cases the function of all the joints is not equally damaged it is in such cases that most is to be expected from a judiciously planned campaign of correction and operation The possible courses of treatment are (*a*) to correct the deformity with the joint in the position of greatest usefulness and to encourage sound ankylosis by long immobilisa tion or (*b*) to correct deformity by operation and at the same time ensure firm ankylosis by arthrodesis though many deny the necessity for the latter step in view of the powerful tendency to spontaneous anklyosis or (*c*) to carry out a mobilising operation such as arthroplasty or pseudarthrosis

Deformity associated with Bony Ankylosis—When bony ankylosis has been allowed to take place in deformity improvement is very difficult to secure for the ankyloses are polyarticular If the patient is young and there is a reasonable prospect of ultimate functional gain correction of the gross deformities by osteotomy may be com bined with arthroplasty of essential joints in a planned campaign of rehabilitation Cases of this nature are formidable and operative treatment should be carried out only in institutions where first class physiotherapeutic after-care and nursing skill of the highest order are forthcoming

The application of these principles to individual joints is briefly as follows —

The Hip Joint—If there is a likelihood of retaining a potentially useful range of movement correction of deformity should be attempted by means of traction through skin extension.

If fibrous ankylosis has occurred and the disease is generalised affecting hips knees and spine correction is not indicated If one hip alone is involved, the deformity is corrected and ankylosis secured by arthrodesis or by long immobilisation If both hips alone are involved an arthroplasty is carried out on one side and on the other the deformity is corrected and ankylosis secured

In the event of bony ankylosis correction under the above con ditions is obtained by osteotomy and realignment of the femur

The Knee Joint—At the knee joint the rheumatoid deformity is

primarily one of flexion but the continued pull of the hamstring muscles may eventually cause a backward subluxation of the tibia on the femur If this is present simple traction only causes further subluxation In order to avoid this, *traction must also be carried out* at right angles to the leg the pull being placed behind the upper end of the tibia

If the hips are hopelessly *disorganised and fixed in flexion correction* of the knees is not justifiable but if the other joints are useful gross disease in one knee may be treated by correction and immobilisation *o obtain sound ankylosis In order to obtain full correction in such a* case it may be necessary to divide the shortened muscles and capsule at the back of the knee (capsulotomy)

When *both* knees are *ankylosed and the hip joints* are good a mobilising operation may be attempted on one side The results are not particularly encouraging for the ligaments of the joint are *generally so disorganised that stability* may be sacrificed or the joint left flail The result of arthroplasty is also uncertain if there is much flexion at the knee before operation

The Ankle—The deformity here is one of equinus and correction can only be obtained by operative lengthening of the tendo Achillis and posterior capsulotomy of the ankle joint After correction fusion may be obtained *either by formal arthrodesis* or by prolonged fixation in plaster

The Foot—Rheumatoid flat-foot is resistant to correction the foot should accordingly be supported by a Whitman's valgus brace In rheumatoid hallux valgus the condition of the joint cannot be improved but if the prominence of the metatarsal head or enlargement of the overlying bursa is a source of pain or inconvenience there need be no hesitation in shaving off the exostosis

Claw toe deformity is very common and very troublesome in extreme examples the toes are subluxated on to the dorsum of the metatarsal heads, and intractable metatarsalgia results Operations on the toes are not generally satisfactory and if the conservative measures of support and padding are of no avail it may be necessary to excise the four lateral metatarsal heads In the great toe the proximal phalanx or part of it is excised

The Wrist Joint—Ankylosis of the wrist in flexion may seriously interfere with the usefulness of otherwise serviceable fingers Excision of the proximal row of the carpal bones may be followed by a degree of movement

The Elbow Joint—A flexion deformity of one elbow should be left alone but if both elbows are ankylosed in flexion and the shoulders and wrists are useful an arthroplasty may be attempted on one side The results however are less satisfactory in rheumatoid arthritis than in ankylosis of traumatic origin

The Shoulder Joint—Advanced disease at the shoulder is associated with ankylosis in adduction and medial rotation Correction is almost impossible to obtain, and the condition of the muscles is a contra indication to either arthrodesis or osteotomy of the humerus Treatment, therefore should not be undertaken

Chronic Villous (Menopausal) Arthritis

The chronic knee arthritis of menopausal women is a crippling disease but in mild cases if treatment is begun at an early stage a considerable improvement may result

At its inception the joint lesion has many of the features of rheumatoid arthritis but there is usually more marked synovial effusion and no tendency to spontaneous ankylosis Pain is common and severe it is diminished but not abolished by rest nor is the swelling greatly reduced by recumbency

In early cases a search is made for possible toxic or septic foci and appropriate treatment should be adopted as soon as one is discovered In addition attention is vigorously directed to the general condition The woman is almost invariably overweight and there are often signs of hypothyroidism A reducing diet is therefore prescribed and supplemented by thyroid extract in doses of a grain thrice daily

The local treatment should commence with a period of recumbency which is continued until there is some improvement both in the condition of the joints and in the patient s weight In working women this is not easy to ensure and in many cases the surgeon has to waive this demand and arrange treatment on an ambulatory basis

Radiant heat massage and active muscular contractions are begun as soon as possible The last two measures are of particular importance for muscular wasting is an early and pronounced local feature In its presence the joint is inadequately protected from minor traumata—especially the constant nipping of the synovial fringes which follows quadriceps insufficiency Quadriceps drill is therefore of superlative importance

A bandage of crêpe or domette over a liberal quantity of wool gives support reduces effusion and affords a sense of warmth and comfort

Pain is treated by analgesics such as aspirin and if sleep is prevented by the aching of the knees chloral and bromide may be allowed at night Local counter irritation may also help to relieve the pain inunction with methyl-salicylate ointment is a favourite remedy but Scott s mercurial dressing is even better It is applied lightly smeared on a square of lint and may be kept on for four days in mild and early cases its efficacy is very marked and the method is well worth a trial

Operation may be required if conservative treatment fails to give relief Synovectomy is the treatment of choice but a more drastic operation may be necessary if osteo-arthritis has supervened (see p 201)

Osteo-arthritis

In osteo-arthritis the articular changes typical of old age occur prematurely and cause great disability There may be a familial tendency to osteo-arthritis and to arteriosclerosis which often occur together Experimental evidence however shows that the main cause is the constant repetition of minor injuries This may be due to the

presence of a loose body to malalignment of the joint surfaces (especially *following a fracture through or near a joint*) or to instability following damage to ligaments In other cases the abnormal stresses imposed by obesity or faulty posture may be responsible

Osteo arthritis is a slowly progressive disease for which curative treatment is not available The clinical course is marked by exacerbations and remissions of symptoms and much can be done to reduce the exacerbations in number and severity If pain is severe and persistent despite conservative treatment arthrodesis may become necessary Elaborate reconstructive operations are seldom justifiable in elderly patients but may occasionally be of value

General Treatment.—Septic foci are eliminated and overweight corrected by suitable dietetic measures The leisured should be advised to reduce unnecessary activities such as shooting and golf Adequate rest should be insisted on and general exercises and massage prescribed for their general toning effects

Local Treatment.—In the early stages the use of heat diathermy and massage usually gives temporary relief X ray therapy is also worth a trial for it gives considerable benefit in nearly 60 per cent of cases After a very short flare up it is usually followed by relief of pain which may last as long as a year Its mode of action is not known and it has no effect on the radiological appearance of the joints

Ultimately more active measures are required as limitation of movement muscle spasm and deformity appear The restriction of movement is primarily due to the impingement of osteophytes or to secondary fibrosis or adhesions in the traumatised capsule adjacent to the outgrowths Pain results when strain is thrown on this part of the joint during movement Protective muscle spasm is evoked to prevent this and long-continued muscle spasm leads to organic shortening of the muscles concerned

Manipulation.—If bony changes are not marked and muscle spasm not severe and especially if the limitation of mobility is apparent only at some point on the range of one or two movements it may be presumed that capsular contraction or an adhesion is the cause In this case manipulation is indicated

The patient is completely relaxed by anæsthesia and the joint moved through its full range of movement in every direction The breaking of the adhesions is often unpleasantly audible After the operation a day or two in bed should be insisted upon and the joint is energetically exercised in the meantime after this free use is allowed and the patient resumes his normal activity

The results of manipulation are often striking and the improvement may last for a period varying from one to six years

Plaster Fixation.—When bony changes are marked manipulation is contraindicated In such cases radical treatment may at once be advocated, or an attempt may be made to give relief by providing the joint with modified rest The application of a plaster of Paris cast is the simplest method of temporarily abolishing movement In the case of the leg the plaster may be an ambulant one a short spica for the hip and a cast from ankle to thigh for the knee but if pain is

severe on weight bearing a period of recumbency is essential If there is much spasm or deformity it may be necessary to employ anæsthesia in order to fix the joint in the proper position It may even be necessary to divide the contracted muscles before the attitude of the limb can be considered satisfactory this is most often required at the hip where the adductors have frequently to be tenotomised at their origin The plaster fixation is continued for four to six months and on removal of the plaster support by firm bandaging knee corset leather hip spica or wrist strap is substituted for a year or more if need be

Operative Treatment.—If these simpler measures are unsuccessful operative treatment is necessary In the choice of operation due regard must be given to the age of the patient the later strain to which the joint is to be exposed and the relative advantages of movement fusion and stability In elderly patients the primary object is to prevent pain by the quickest and easiest method In younger patients the functional result demands more consideration

Arthrodesis.—Fusion of the joint surfaces is a certain method of relieving the pain of osteo-arthritis and in many situations the function of the limb afterwards is admirable It is excellent at the knee and at the ankle but at the hip it is only partly or temporarily of benefit since it throws a considerable strain on the joints of the lumbar spine The absence of a natural tendency to ankylosis and the essentially degenerative nature of the disease make successful arthrodesis difficult to obtain the technique has accordingly to be carefully selected and immobilisation long continued

Reconstructive Procedures—These all aim at the relief of pain while leaving a movable joint

Cheilotomy consists of the removal of the marginal outgrowths and has been recommended in cases of localised osteophyte formation without generalised bone changes The procedure is not a sound one and should not be practised save as part of a larger scheme of reconstruction

Arthroplasty is the most elaborate of the reconstructive operations and is of necessity an extension of the previous procedure the recon structed surfaces are covered with fascia or other material or otherwise rendered smooth to prevent new bone formation between them and to facilitate movements without friction In successful cases a new joint cavity lined by fibrous tissue is formed and the function is very satis factory Unfortunately the result is often disappointing since in most joints the excision of the joint surfaces leaves a considerable disparity in their respective sizes This is not only a potential cause of further osteo arthritis but also causes instability The operation is in practice almost confined to osteo-arthritis of the elbow and of the hip and the best results have been obtained in the latter joint The essentials of the operation there are a generous removal of the acetabular margin (acetabuloplasty) and the application of a vitallium cap over the remodelled femoral head (p 332)

In elderly subjects an attempt to restore a degree of movement may also be called for in bilateral hip disease Formal arthroplasty is best avoided in such subjects but a simple and effective pseudarthrosis may

be obtained on one side by the method of Sir Robert Jones In this operation stability is deliberately sacrificed to mobility

Palliative Procedures.—*Osteotomy* at the hip gives relief of pain by transference of the body weight directly to the femur below the level of the joint This is effected by osteotomy with displacement of the lower fragment inwards to the side wall of the pelvis the joint being thus short-circuited This is an excellent and reliable procedure it is particularly applicable in old subjects and it is easy and quick to perform and there is no appreciable shock

Drilling of the bone close up to the articular surface has been practised to enable new vessels to grow into the canals so formed and revivify the joint structures This it generally fails to do but in some cases pain is relieved possibly by the evacuation of pockets or cysts of degenerated bony tissue held under tension Even this cannot be guaranteed however and the method cannot be recommended

Denervation of the joint has been advocated as a pain relieving measure at the hip and elbow It is obviously difficult to interrupt all the sensory supply but good results have attended obturator neurectomy for hip disease

Removal of loose bodies or detached osteophytes obviates the pain of repeated locking and may arrest the progress of the disease but the patient should be informed that the convalescence may be prolonged and that the operation is not for the cure of the osteo-arthritis

HÆMOPHILIC ARTHRITIS

In hæmophilic subjects even a mild injury may cause severe intra articular hæmorrhage with rapid distension of the capsule As a result of repeated attacks of hæmarthrosis permanent hyperplastic changes occur in the synovial membrane and patchy ulceration of the articular cartilage and cavitation of the subchondral bone supervene Eventually the typical changes of osteo-arthritis appear The knee joints are the most frequently affected on account of their special liability to injury

Treatment.—In the early stages in addition to the usual treatment of the hæmophilic state the patient is put to bed and aspiration of the joint carried out with full aseptic precautions A firm compression bandage is then applied over several thicknesses of wool and the limb comfortably splinted

In the stage of chronic arthritis the usual measures are employed If deformity has been allowed to develop as a sequel to earlier attacks attempts may be made to correct it by gentle non-operative means such as gradual traction or serial or wedge plasters Operative correction for obvious reasons is contraindicated

J B

CHAPTER XII

TUBERCULOSIS OF BONES AND JOINTS

TUBERCULOSIS of bones and joints most commonly affects the spine the hip and the knee less often the joints of the upper limb and occasionally any bone or joint In Britain it is a disease of considerable frequency and an important cause of crippling in children and adults

The principles of treatment of this disease are based upon our knowledge of its etiology Tuberculous disease never arises primarily in a bone or joint it invariably reaches that situation as a result of dissemination from a primary focus in the lungs or in mediastinal or abdominal glands In some cases the primary focus is quiescent or in a state of healing but in others it may be active and progressive Moreover since the lesion in the bone or joint develops as the result of blood borne dissemination of the tubercle bacilli it follows that other hæmatogenous lesions may coexist Thus it is not uncommon to find two or more foci in different parts of the skeleton for example in the spine and the hip joint or to find a focus in the skeleton accompanied by a lesion in the urinary tract

From these observations it is clear that treatment must not be aimed solely at the extirpation or healing of the obvious focus in the bone or joint but must include measures designed to raise the patient s general resistance to tuberculosis

General Treatment.—It is highly desirable that patients with active skeletal disease should be admitted to a sanatorium where the general treatment can be carried out under optimum conditions and where in addition the morale (and in children the education) can best be maintained during the necessarily protracted and sometimes dispiriting course of the disease

A sanatorium régime comprises treatment in the open air exposure to sunlight (natural or artificial) proper feeding and good nursing Sanatoria are located as far as possible in healthy situations with low rainfall, free from ground mist and fog Their wards are built with verandas to permit nursing in the open air through the greater part of the year In the winter months heliotherapy should be supplemented by ultraviolet irradiation from carbon arc or mercury vapour lamps Heliotherapy and ultraviolet irradiation should be so controlled as to bring about gradual tanning of the skin with no painful erythema or blistering They should be given very guardedly however in the presence of active lung disease when excessive irradiation is apt to be harmful.

The recent introduction of streptomycin and p-aminosalicylic acid (P A S) have provided new measures for the specific treatment of tuberculosis and while they are still in the experimental stage there is good evidence of their value This is particularly obvious in cases with abscess formation or sinuses In some clinics mostly on the continent of Europe the protection afforded by these drugs has encouraged a bolder outlook from the point of view of surgery and such operations as excision of tuberculous joints again show signs of coming into favour

The medical and nursing care of bone and joint tuberculosis requires special attention Doctor and nurse must understand the aims of treatment and especially the need for uninterrupted immobilisation of the affected part They must be familiar with the type of splintage and be able to make the necessary adjustments in the apparatus used Lastly they must always be on the lookout for evidence of progress of the disease and for signs of a developing cold abscess

The formation of urinary calculi is a common complication in bone or joint tuberculosis treated by recumbency This complication results in all probability from the combined effects of many factors including stasis of urine in the renal pelvis due to the recumbent position high concentration of the urine due to sweating from overexposure to the sun and an increased urinary output of calcium due to skeletal atrophy To prevent the stone formation excessive heliotherapy must be avoided and bland fluids should be given in large quantities to ensure dilution of the urine Where it can be arranged without impairing the immobilisation of the affected joint the position of the patient should be altered at regular intervals so that any crystals deposited in the renal pelvis may be expelled in the urine

Local Treatment.—The local treatment of the affected part varies The ideal treatment would be to eradicate the focus by operation and this can be done in the knee and a few other situations but in the great majority of skeletal lesions no such extirpation is possible and reliance must be placed upon conservative measures designed to assist the natural processes of healing and repair The essence of conservative treatment is to put the affected part completely at rest and to maintain it at rest for a very long period until such time as healing has taken place

In selected cases immobilisation may be rendered more complete by operative methods designed to provide internal splintage of the diseased part for example Albee s bone-grafting procedure for spinal disease and various forms of arthrodesis Such operative intervention cannot take the place of prolonged recumbency and splintage —though it may hasten convalescence—and its main value is by permanently immobilising the diseased part to minimise the risk of recurrence

The length of treatment by recumbency must be varied according to the progress of the disease This should not be judged by the results of clinical examination which are somewhat unreliable but by the appearance seen in successive X ray pictures which should be taken as a routine every three months during the whole period of treatment

In the active stage of disease the X ray picture is characterised by marked decalcification at the site of disease by a general "woolliness" caused by loss of the normal trabeculation and perhaps by visible cavitation within the bone It is a common experience that during the early months of treatment and despite improvement as judged clinically X ray examination shows that the disease continues to progress Later this progress is arrested and finally the healing process very slowly becomes manifest Only when the trabeculation is again visible and the area has been recalcified is it safe to allow the period of recumbency to end In spinal disease the average period is about two years in hip disease about eighteen months in other lesions slightly less

The aim of treatment in the case of the spine is to have the focus of caseation walled off by fibrous tissue and the affected vertebral bodies sufficiently recalcified and rigid to resist deformation under the body weight In the case of joint disease the aim varies under different circumstances In young children unless the disease is virulent and the resistance poor there is a fair prospect of the lesion healing without much limitation of movement In older children and adults on the other hand healing can be achieved only at the cost of ankylosis and the more complete the ankylosis the more certain the cure In these cases therefore osseous ankylosis is desirable though in practice it is rarely obtained unless the disease is complicated by sinuses and superadded pyogenic infection The common result in uncomplicated disease treated conservatively is a fibrous ankylosis of variable degree permitting movement of 5 to 30 per cent of the normal range

Since ankylosis is both expected and desired it is clearly important that the affected part be immobilised in the optimum position This involves no special problem in cases coming for treatment early but is a matter of some difficulty in cases in which deformity has already occurred. In such cases where the joint disease is at an early stage and the deformity is due partly to spasm or to soft adhesions it can sometimes be corrected by gradual traction (never by forcible manipulation) In late joint disease it is generally wiser to leave the deformity uncorrected for fear of lighting up the infection and compensate for it at a later stage by osteotomy In the spine also it is generally unwise to correct an established deformity

Treatment of Cold Abscesses.—A deeply placed cold abscess of small size requires no special treatment An abscess which is enlarging and coming towards the surface must on the other hand be treated promptly to prevent the development of a sinus

Repeated aspiration of the abscess is the method of choice For this purpose a wide bore needle should be introduced under local anaesthesia and as much as possible of the fluid or pus aspirated. To avoid the risk of infection spreading along the needle track and so leading to the formation of a sinus the needle should be inserted through healthy skin some distance away from and above the centre of the swelling and passed obliquely into the abscess cavity so as to form a valvular track Aspiration may require to be repeated on several occasions at weekly intervals In favourable circumstances the abscess then ceases to fill up and gradually shrinks

Aspiration of the abscess will fail if the pus is too thick to be withdrawn or if it contains much caseous matter In such cases some surgeons recommend the injection of irritant fluids such as 10 per cent iodoform in ether with aspiration repeated a week later This method is not often practised now however and if simple aspiration fails it is generally preferable to empty the abscess by operation The abscess is exposed through a short incision made preferably through intact skin some little distance from the centre of the swelling and the pus and caseous matter evacuated The granulation tissue lining the abscess wall is then removed as far as access permits by a sharp spoon the whole cavity swabbed dry and the wound closed Subsequent aspiration may be required on one or two occasions if the abscess refills

Treatment of Tuberculous Sinus.—This is one of the most difficult problems in surgery for a tuberculous sinus is often long narrow and tortuous it is lined by fibrous tissue and tuberculous granulations and transmits infective pus from an active focus of disease A sinus is unlikely to close while the primary focus is active it may close when the primary focus heals or may persist

In most cases the treatment of the sinus is on conservative lines. Great care must be taken by cleanliness and the use of aseptic dressings, to prevent superadded infection by pyogenic organisms Ultraviolet irradiation is helpful to promote a reaction in the skin surrounding the mouth of the sinus. Streptomycin is particularly valuable The injection of iodoform and bismuth either alone or in combination was formerly advised but is of doubtful value Operation is indicated if the sinus is a short one communicating directly with a focus of caseation or if the sinus is chronic and has rigid fibrotic walls The operation consists in enlarging the orifice of the sinus and curetting its lining of granulation tissue In some cases the sinus can be followed up as far as the primary focus and accessible caseous matter débris and fragments of necrotic bone may then be removed by curettage

TUBERCULOSIS OF THE SPINE (Pott's Disease)

Here the local treatment is by *prolonged immobilisation in recumbency with fixation in suitable apparatus. In certain cases the fixation may be assisted by bone grafts (Albee's operation)* Subsequently when the patient is allowed up the spine must be supported by a suitable jacket or brace A cold abscess (*e.g* psoas abscess) may require to be treated as described above

The *period of recumbency* varies from one and a half to two and a half years, and must be decided in each case on the findings in serial X rays Various types of apparatus are used by different surgeons to immobilise the spine For adults a plaster bed is most satisfactory It is made by moulding wet plaster bandages to the patient as he lies prone The plaster is reinforced by strips of duralumin and lined by felt. It is supported on a wooden frame a few inches off the bed so that a bed pan may be slipped in place without moving the patient When the disease affects the dorsolumbar or lumbar region—the usual

sites—the plaster bed should support the trunk and thighs (some surgeons prefer to support the legs and feet also) When the disease is higher the head also must be supported and immobilised while in

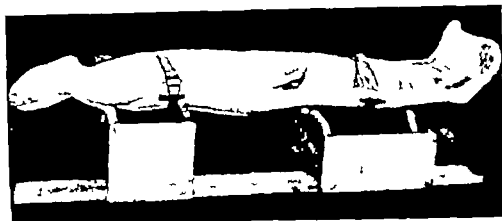


FIG 66
Dorsal plaster shell, lined with felt used for a case of spinal tuberculosis in which immobilisation from the occiput to the feet was required. The wooden support facilitates nursing and enables the patient to be carried from place to place

some cases it is necessary to apply traction to the head by weight and pulley (2 to 4 lb) taking the pull from a leather strap fitting round the forehead and suboccipital region

For children a satisfactory appliance is a Whitman frame which consists of a narrow rectangle of iron tubing with sheets of canvas stretched tightly across The child lies on the frame and is held in position by straps round the chest and ankles The Whitman frame may be angled at the level of the disease to suit each individual case Its particular ad vantages are that it allows the child to be moved easily from place to place and that it can be cleansed readily when soiled. As an alternative the child may be strapped on a Thomas spinal frame—a leather padded iron frame which supports the whole trunk and lower limbs—or one of its modifications such as the Pyrford frame

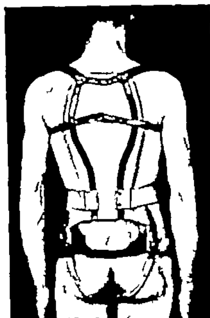


FIG 67
Spinal brace The two curved vertical steel strips are fixed to the pelvic band. Shoulder straps, perineal straps, and a waist band hold the brace in position

During the period of recumbence special attention must be paid to the risk of urinary stone formation (see p 204) and a watch must be kept for the development of cold abscesses

Subsequently when the period of ambulant treatment is started, the spine must be supported by some form of apparatus The plaster of Paris jacket is no longer advised A preferable appliance is a jacket or support made of fabric stiffened with celluloid or certalmid,

moulded to the individual patient Alternatively a spinal brace of light spring steel may be used This may require to be worn for two years or longer

Albee s bone-graft operation is advised in adults when the initial activity of the disease has been overcome It is designed to bring about fusion between the spinous processes in the affected region and thus to form an internal splint to immobilise the part permanently and strengthen the spine to resist deformation under the body weight It is suitable only in cases where no marked kyphosis is present

The technique is simple With the patient prone an incision is made in the mid line posteriorly curved slightly to avoid leaving a scar in the median furrow where healing is slow The access is deepened in the mesial plane to expose the spinous processes of the affected and adjoining vertebræ—five or six in all The processes are then split



FIG 68

Whitman frame of iron piping, canvas covered used in the treatment of a case of tuberculosis of the thoracic spine

in the median plane with an osteotome (a difficult matter as they are often atrophic and thin) and the halves levered apart so that when the intervening interspinous ligaments are split a gutter is formed 5 or 6 in long with the split spinous processes embedded in the sides and the laminæ exposed at the foot

One knee is then flexed acutely and a long curved incision is made in the leg to expose the subcutaneous surface of the tibia The periosteum is reflected as a flap and the bone laid bare A graft is then taken of a shape to fit the spinal gutter A strip of lead or aluminium is useful at this stage as a template The graft is best taken out by means of a double circular saw driven electrically It is transferred and embedded in the spinal gutter where it is held in place by suturing the overlying soft tissues.

After an Albee operation the patient should be nursed in the prone position on a ventral plaster bed or other apparatus and recumbency should be maintained for at least two months.

Pott's paraplegia is paralysis resulting from involvement of the spinal cord. Sometimes it is due to œdema and vascular changes at the level of the spinal disease In other cases it may be due to mechanical pressure on the cord by a cold abscess a solid caseous mass the hard bore of the internal gibbus or a loosened intervertebral disc which has become displaced into the spinal canal. It is noteworthy that the

paralysis mainly affects the anterior aspect of the cord, with motor paresis jerking movements and contractures and sphincteric loss

In mild cases no special treatment is required for the paresis which tends to recover as the bony disease heals If the disease involves the upper cervical vertebræ and in any case in which jerking movements intervere with the immobilisation skeletal traction should be applied by means of a skull calliper attached to a rod projecting up from the head end of the plaster bed Counter traction is obtained by raising the head of the bed

In chronic cases showing no improvement and in cases where the paraplegia is progressive operation is advisable to relieve the cord pressure In acutely progressive cases the operation should be performed as a matter of urgency A curved incision is made to one side of the gibbus Superficial muscles are displaced laterally, while the erector spinæ is displaced medially to give an imbricated closure and prevent post-operative sinus formation The posterior ends of several ribs are taken away with the corresponding transverse processes

The pedicles and adjacent parts of the vertebral bodies are next removed to gain access to the spinal canal The anterior aspect of the theca can now be inspected and the cause of the pressure demonstrated and removed. This operation is less difficult than might appear for owing to the gibbus which is usually present the site of disease can be approached directly from the lateral side

TUBERCULOSIS OF THE SACRO-ILIAC JOINT

In this disease the symptoms are insidious and the first sign often is the appearance of a cold abscess which may come to the surface either medial to the anterior spine or posteriorly The local treatment is concerned first with evacuation of the abscess preferably by repeated aspiration or if this fails by operation

The sacro iliac is a difficult joint to immobilise by splintage and in most cases it is necessary to advise recumbency on a plaster bed or spinal frame for a long period If the general condition permits arthrodesis of the joint should be carried out The customary method is to gain access through a curved incision over the posterior part of the iliac crest and to implant a bone graft conveniently taken from the iliac crest so as to obtain fusion between the posterior parts of the ilium and sacrum and thus provide internal splintage of the joint After operation recumbency should be maintained for about three months Later the patient should be fitted with a spinal brace or jacket

TUBERCULOSIS OF THE HIP

The local treatment must be designed to immobilise the hip in its optimum position, abducted 10° flexed 10 and neutral as regards rotation In the great majority of cases the patient should

kept in bed during the active phase of the disease until X ray mination shows evidence of healing and subsequently when the ent is allowed up some form of splintage must be continued for a ; time to prevent recurrence

During the period of recumbency various types of apparatus may used to ensure fixation of the joint Some surgeons advise a plaster Paris cast which to control the hip adequately must extend from thorax to the toes and may require to include also the opposite h Such an extensive cast however, prevents the proper care of skin and interferes with heliotherapy For this reason most eons prefer to use various modifications of the Thomas hip splint, ather padded iron frame on which the patient lies supine with trunk and lower limbs immobilised by straps An even simpler hod, especially for young children, makes use of a tilting bed limb is fixed by adhesive tapes to the foot of the bed, which is d 20 to 30° The body weight by exerting traction immobilises hip and tilts the pelvis thus producing abduction

Operative treatment is indicated only occasionally in hip disease then mainly in adults Two types of operation have been described extra articular arthrodesis in which a bone graft is laid across the from the great trochanter to the upper rim of the acetabulum provide an ' internal splint and the intra-articular arthrodesis, which the hip joint is opened, all diseased tissue removed and remaining cartilage curetted away with a view to encouraging losis

Cold abscesses require treatment on the lines already indicated. y generally appear on the medial side of the thigh less often laterally the vicinity of the anterior superior spine

After the period of recumbency ambulant treatment must be main ed for a year or more During this phase the hip should be im llised either by a plaster of Paris cast or by a moulded splint of io impregnated with celluloid or certalmid At first the patient ld use crutches, and he should wear a low patten on the opposite to swing the affected limb off the ground Later the patten is oved and weight bearing is allowed

TUBERCULOSIS OF THE KNEE

Here the local treatment varies according to the age of the patient young children conservative treatment may be expected to lead to ing and leave free movement at the joint In older children and t adults, healing can only be achieved at the cost of ankylosis and can be gained most quickly and surely by the operation of excision ne knee In a few adults mainly elderly persons with poor resis e where the disease is very active or complicated by sinuses and radded infection it is necessary to advise amputation.

Conservative treatment implies immobilisation in optimum position w degrees short of full extension Generally in the early stages should be carried out with the patient in bed the knee being

immobilised on a splint Weight traction through adhesive strips applied to the leg assists the fixation and also tends to prevent destruction of the joint cartilages by mutual pressure Later the patient may be allowed up the knee being immobilised in plaster of Paris (which should extend from the pelvic brim to the toes) At this stage no weight bearing is allowed crutches are used and a patten is worn under the boot of the sound limb If healing proceeds satisfactorily splintage may in due course be discontinued and gentle movement of the joint allowed Last of all weight bearing is permitted

Excision of the knee is advised in most patients over the age of fifteen and in younger patients if conservative treatment fails A U-shaped incision is made dividing the patellar ligament and the extensor expansion The whole extensor apparatus including the

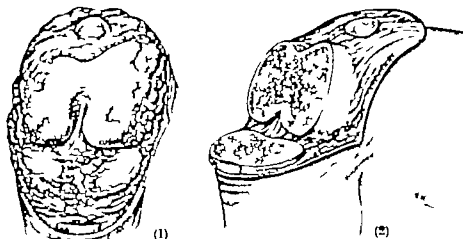


FIG. 60

Excision of the knee for tuberculosis. (1) The U-shaped flap turned up to expose the joint. (2) Diseased synovial membrane excised and the bone ends removed.

patella is then reflected upwards and the cruciate and collateral ligaments are divided so that when the limb is powerfully flexed the whole joint is laid widely open (Fig 60) All the diseased synovial membrane which may be ½ in thick, including the synovial membrane lining the suprapatellar pouch is then cut away Bursæ such as the semi membranosus bursa which communicate with the joint are dissected out and excised The articular surfaces of the femur tibia and patella are then removed with a saw care being taken in young subjects not to encroach upon the epiphyseal cartilages

In the case of the femur and tibia the saw cuts which may be straight or curved are so planned that the raw ends of the two bones may be brought into accurate apposition with the limb in optimum position The divided patellar tendon and extensor apparatus are then sutured the wound is closed and the limb encased in plaster of Paris

Generally the knee should be fixed in a position of 180 extension, for this gives a very stable limb which being shortened an

inch or so by removal of the bone ends can readily be swung forwards off the ground in walking Such a stiff but painless limb causes very little disability In women, however and clerical workers, some surgeons prefer to have the knee flexed about 15° for convenience in sitting

Tuberculosis of the Ankle.—Here in addition to disease of the synovial membrane there are often foci in the adjacent bones especially the talus Sinuses are common especially on the postero-lateral aspect of the joint The peroneal tendon sheaths may also be affected

Conservative treatment consists of prolonged immobilisation in plaster of Paris and is sometimes successful but more often the disease progresses despite fixation In these circumstances if no bone foci are visible on X ray examination the operation of synovectomy is sometimes effective The joint is exposed through a lateral J-shaped incision the peroneal tendon sheaths if diseased are excised and all thickened synovial membrane is cut away If the articular cartilages are diseased they may be shaved off, and any superficial bone foci may be curetted. If the talus is extensively diseased it may be removed After any such operation the limb must be immobilised in plaster of Paris for several months

In many cases of tuberculosis of the ankle the most satisfactory result is obtained by early amputation at the mid leg

Tuberculosis of the Tarsus.—*Occasionally an isolated tuberculous* focus develops within one of the bones of the tarsus especially the calcaneus and cuboid It should be treated by thorough curettage followed by immobilisation in plaster of Paris

More commonly the disease also affects the tarsal joints and is apt to cause much destruction with abscess formation and sinuses. In young children good results can often be obtained by conservative immobilisation in plaster In adults it is generally preferable to advise amputation

Tuberculosis of the Shoulder—Here the disease is usually of comparatively mild type and healing may be obtained by conservative methods though at the cost of ankylosis The limb should be fixed in the optimum position (abducted 70 and with the elbow brought forward to the plane of the sternum) in plaster of Paris or an abduction splint until X ray examination indicates that healing is well advanced

Tuberculosis of the Elbow—*Here also the disease is usually of mild* type and responds well to conservative treatment by fixation in plaster The limb should be fixed in optimum position a little above the right angle Operation is required only occasionally to curette an isolated bone focus *e.g* in the olecranon or to scrape an abscess or sinus

Tuberculosis of the Wrist and Carpus.—In this rare form of tuberculosis the disease commonly affects the radius the carpal bones and the intervening joints It causes much destruction of bone and often *leads to the formation of a cold abscess and sinuses* Generally the best treatment in the early stages is to immobilise the part in plaster of Paris in a position of dorsiflexion Later it may be necessary to open a cold *abscess and curette the osseous foci*

Isolated Tuberculous Foci in Bones.—Occasionally tuberculosis affects bones in sites unrelated to joints, *e.g.* the sternum ribs ulna, tibia and the phalanges The disease may excavate the bones widely or may originate under the periosteum and spreading superficially leave the deeper part of the bone intact The treatment is generally on conservative lines at first If feasible, the part may be splinted or immobilised in plaster of Paris Later if a cold abscess forms or there is a large cavity in the bone operation should be carried out to evacuate the pus caseous matter and granular débris and to curette the lining membrane

C F W I

REFERENCE

DOTT N M (1947). "Skeletal Traction and Anterior Decompression in Pott's Paraplegia" *Edin med J* **54**, 620

CHAPTER XIII

PARALYSIS AND CONTRACTURE

ACUTE ANTERIOR POLIOMYELITIS

THIS is an acute infective fever occurring in sporadic or epidemic form and affecting mainly children In Great Britain epidemics are of minor degree and usually occur in the summer or late autumn The cause is believed to be a filterable virus which exerts its effects chiefly on the central nervous system Accompanying the general manifestations of an acute fever there is the onset of paralysis and muscle tenderness at first widespread and due to the pressure effects of acute inflammatory disturbance exerted on the cells of the anterior horn of the spinal cord As the products of inflammation are absorbed there is partial recovery the residual paralysis being related to areas of the cord irreparably damaged and destined to become later the seat of neuroglial over growth The residual paralysis affects the lower limbs more often than the upper limbs In the lower limb it affects especially the muscles controlling the upright posture—the gluteal group at the hip the quadriceps at the knee the dorsiflexors and plantar flexors of the foot In the upper limb the deltoid, the extensor pollicis opponens pollicis and biceps are affected in this order of frequency Abdominal and spinal muscles are always involved in widespread paralysis and some residual disability in these is common

Principles of Treatment.—In the early stages the patient should be isolated as in other infectious fevers No drug is known to affect the progress and the use of convalescent serum has not fulfilled early expectations Headache may be relieved by aspirin or by repeated lumbar puncture At this stage supported exercises in a hot bath are beneficial in relieving pain in muscle groups and also facilitate both passive and active movements to stiff joints In the case of young children this can be carried out in an ordinary bath and in adults in a heated remedial pool

Splintage should be applied early to relax all paralysed muscles and support relaxed joints *Splintage must be adequate and must be maintained continuously for a long time* Throughout the period of splintage the joints should have light passive exercises to prevent joint stiffness, but these should be carried out under careful supervision to prevent undue stretching of the paralysed muscles

If opposing muscle groups are involved the joints should generally be immobilised in neutral position *later when recovery of one group declares itself* the splintage may be adjusted accordingly The position

for immobilising a joint may be modified to suit the ultimate function of the part For example the elbow should always be flexed, for gravity will always allow of extension even though the extensor muscles remain paralysed

All splints must be comfortably fitted and padded the limbs being enclosed in wool and lightly but firmly bandaged

Massage and electrical stimulation should not be carried out in the early stages as they only irritate the sensitive muscles Complete rest for the muscles is essential and it is wise to emphasise this to the parents to explain the apparent inactivity of treatment

When the acute phase is over and the first signs of recovery appear active treatment is started to fan the flickering flame of returning function This stage is denoted clinically by the dis appearance of muscle tenderness and a flicker of movement in a previously paralysed muscle It is usually evident first about eight weeks after the onset

Re-education is achieved by gentle exercises, carried out so as to stimulate the returning muscle power without however fatiguing or overstretching the weakened muscles Each effort at movement is made with the muscle in such a position that it is completely relaxed and the pull of gravity eliminated It is most important that the exercises should always be stopped before muscle fatigue is induced There is no stage of treatment so dependent on expert guidance and the co-operation of a skilled medical gymnast with detailed knowledge of muscle function is more valuable than any electrical equipment

Re-education starts while the patient is recumbent and must be continued in the ambulatory stage Recovery of function during this period is most marked in the first six months but may extend up to two years

In mild cases especially affecting the upper limb the patient may be allowed up early but in the majority of cases the minimum period of recumbency is six months and in widespread infections involving the spinal and abdominal muscles it may extend to eighteen months

In this stage the treatment must still include both re-education and splintage The latter is necessary to prevent overstretching of partially recovering muscles and to prevent the development of deformities It must be remembered that many of the gross deformities of infantile paralysis are due to neglect of splintage at this stage

The treatment of infantile paralysis is not complete without atten tion to the patient's future employment Accordingly in severe cases as in all other long term orthopædic conditions vocational training should be instituted as soon as the patient s condition permits

Methods of Splintage.—Where there is generalised infection with involvement of all four limbs and trunk, the patient should be encased in a complete plaster shell or placed on a Jones abduction frame

Where the paralysis is limited in extent the following lines of treatment should be adopted

Upper Limbs—The shoulder should be abducted to 90° the elbow flexed to at least a right angle the forearm in mid prone position,

the wrist in 20° dorsiflexion, fingers flexed to 30 at the metacarpo phalangeal and interphalangeal joints (i e hand held as in grasping a large ball) An aeroplane splint is eminently suitable for this the best being Littler-Jones splint in combination with a support to the *wrist and fingers* *The Littler-Jones' splint must be measured to suit* the individual patient It is essential that the lower rim bears against the pelvis below the iliac crest to obviate lateral tilting of the trunk which may lead to scoliosis

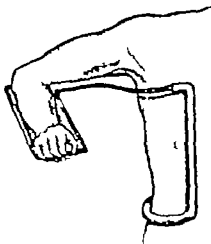


Fig 70
Littler-Jones abduction splint

To maintain the elbow flexed without constricting pressure a collar and cuff gives adequate support A short cock up splint suffices to support the extensors of the wrist a long cock up to support *the extensors of the fingers* *A thumb* piece may be added to protect the ab ductors and extensors of the thumb

The Trunk —The patient should be supine with no tendency to lateral devia tion *as this is apt to allow the insidious on* set of scoliosis If the abdominal muscles are weak the shoulders may be slightly elevated The most suitable splintage for this region is a plaster of Paris shell

During ambulant treatment a support is required sufficiently firm to control the spine but light enough to be borne comfortably A Thomas back support is excellent when there is no great tendency to lateral deviation otherwise a leather or celluloid jacket built on a plaster mould taken from the individual patient is advisable

Lower Limbs —The hip joints should be in 20 abduction due attention being paid to the balance of power in flexors and extensors A muscle which frequently causes later deformity is the tensor fasciæ femoris its subsequent contracture being a common cause of *flexion* deformity of the hip The knees should be in extension with a firm pad behind the joint to prevent stretching of the joint capsule and a later genu recurvatum The feet are kept at right angles with due attention to the relative power of the invertor and evertor muscles

During recumbency a *Thomas bed splint with right-angled foot* piece is suitable for this purpose or a plaster of Paris shell may be used For ambulant treatment where the muscles controlling the hip are affected a leather or celluloid support is most satisfactory It is built to a special plaster mould made from the individual patient and includes a jacket fitting the trunk and a thigh piece extending to the knee

Where the muscles controlling the knee are affected a Thomas calliper is suitable This splint which is somewhat similar to Thomas bed splint is shaped at its upper end to fit accurately to the thigh and pelvis while the lower ends of its lateral members are angled to fit into holes drilled into the heel of the boot Leather straps may be incorporated to correct a tendency to knock knee or bow leg or to prevent inversion or eversion of the foot

Where the muscles controlling the ankle and foot are alone affected support may be provided by "short irons" fitted to the heel of the boot and extending up to the level of the tibial tuberosity To correct eversion a lateral iron is used, with a strap encircling the leg of the boot To correct inversion a medial iron is used similarly Where more rigid support is required a double iron may be used A "check stop" may be added to prevent drop-foot The sole and heel of the boot should be adjusted to suit the condition Thus to correct eversion they should be wedged on the medial side to control inversion on the outer side To compensate for shortening of the limb both sole and heel should be raised

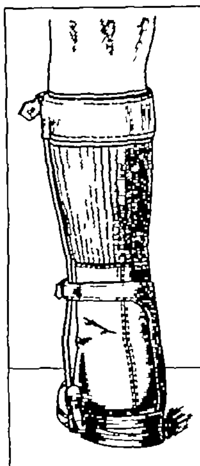


Fig 71
Short outside iron and drop-foot stop Heel raised on medial side

In extensive paralysis affecting the trunk and both lower limbs a spinal support and double caliper splints should be fitted Using crutches the patient can then swing the flail limbs under him—the tripod gait

Operative Treatment.—Operation is considered only when all hope of further recovery is past a period of at least two years. Operation may be indicated to utilise available muscles to best advantage by transplanting their tendons to stabilise a flail joint to lengthen a short limb or to overcome deformities resulting from contracture

In deciding the need for operation it is important to remember that many patients learn trick movements to aid function which are more useful than the orthodox procedures of surgery

Tendon Transplantation.—This is an attempt to use the available muscles to best mechanical advantage It has a very limited field of application, and certain conditions are required for its success —

(a) The transplanted tendon must be strong enough for the new function required of it
(b) It must be capable of being trained to its new function and should replace the action of a muscle it has been aiding previously As a general rule antagonists are poor transplants
(c) Its line of action should be as straight as practicable
(d) It should not be transplanted in the presence of a fixed deformity
(e) It should be sutured to its new position under *tension*, and preferably embedded into bone

In the upper limb the opportunity for tendon transplant rarely occurs in infantile paralysis but occasionally transplant of the wrist

flexors to act as extensors of the fingers and thumb is a useful procedure This operation is more commonly performed for irreparable damage of the musculospiral nerve

Operation for Simian Thumb—Where the power of abduction and opposition of the thumb is absent this useful movement may be restored by transplanting the tendon of flexor digitorum sublimis from the third or fourth finger This tendon is threaded through a loop of tissue fashioned from the flexor carpi ulnaris at the wrist and thence passed subcutaneously to the proximal phalanx of the thumb where it is anchored in a tunnel in this bone After operation the thumb is held in plaster of Paris in the position of opposition for approximately four to six weeks Alternatively the bone block operation described on p 210 may be performed

In the lower limb the tensor fasciæ latæ or the sartorius may be transplanted to give extension of the knee in paralysis of the quadriceps while the tendon of the tibialis anterior may be transplanted to prevent inversion of the foot in paralysis of the peroneal muscles

The technique of these operations is described in the regional chapters.

Procedure for Transplant of Tensor Fasciæ Latæ—A lateral incision is made in the thigh extending from the base of the great trochanter to the lateral aspect of the patella A strip of fascia lata 2 in broad is demarcated at the upper limit of the incision and detached at its lower end lateral to apex of patella It is then raised still attached at its upper origin threaded from the upper end down the tendon sheath of rectus femoris and sutured under tension at its lower end through a drill hole in the patella The limb is maintained in 30 flexion at the hip in a Thomas bed splint and graduated muscle re-education begun in two to three weeks The patient is allowed up in a walking caliper in approximately eight weeks and discards this gradually as the transplant gains in power

Similar operative procedure may be performed for the sartorius through a medial incision

Stabilising Operations—A flail joint may be stabilised by arthrodesis In infantile paralysis the most successful stabilising procedures are for the shoulder and the joints of the foot As a general rule the knee hip and spine are better stabilised by suitable splintage than by operation

Shoulder Joint—In paralysis of the deltoid there is loss of active abduction of the shoulder Trick movements may occasionally compensate for this but in many cases these are not possible Where the function of the elbow and hand is good and in the presence of strong active scapular muscles it is possible by arthrodesis of the shoulder joint to transmit the scapular movement to the arm

An incision 6 in long is made with its centre over the tip of the acromion The atrophied deltoid makes exposure of the head of the humerus simple and the joint is opened by incision of the capsule The long head of biceps tendon is retracted medially and all cartilage removed from the adjacent surfaces of humeral head glenoid cavity and under surface of acromion The latter is partially divided some 3 in. from its tip and turned downwards to form a flap of bone The arm is fixed in 70° abduction and 40 anteflexion at the shoulder

in a plaster of Paris spica, and kept at rest for about six months Exercises are begun from an abduction splint thereafter, and the patient ultimately develops a 90° abduction range

Bone Block Operations—These are designed to provide a bony buttress for restriction of movements at a joint, and in this way to aid the function of a weak group of muscles In paralysis of the flexors at the elbow a transverse graft from the ulna may be placed across the olecranon fossa to check extension beyond a right angle In paralysis of the thumb where power of abduction and opposition is lost—' Simian thumb'—a strut of bone may be placed between the first and second metacarpals to maintain the opposed position in this way aiding greatly the function of the hand

Bone Lengthening—This procedure is carried out where there is considerable shortening in one lower limb The operation may be performed on femur or tibia and fibula

Femur—The shaft of femur is exposed by lateral incision The bone is divided along its length for 4 to 5 in and at either end of this incision half the circumference of femoral shaft is divided on alternate sides to leave two long overlapping fragments Skin only is sutured and by means of continuous traction in a Thomas splint as much as 1 to 2 in of distraction may be obtained

Tibia and Fibula—The tibia is divided in a manner similar to that of femur and the fibula divided by transverse osteotomy Two pins are inserted well above and below the site of division of tibia and the limb gradually stretched in a special traction apparatus This must be done slowly to prevent trophic disturbances and requires the co-operation of a skilled team

Shortening of the sound leg is a simple procedure to equalise the length of the lower limbs and is carried out on the femur of the sound side by removing a section of bone of the required size

SPASTIC PARALYSIS

In the infant spastic paralysis is associated with lesions of the cerebrum due to maldevelopment trauma or infection In the adult it is commonly the result of disease of the central nervous system as in disseminated sclerosis, or it is secondary to lesions of the cardiovascular system such as cerebral hæmorrhage or thrombosis The paralysis is of upper motor neurone type and the resultant spasticity leads primarily to muscular inco-ordination, and later to deformity from contracture of certain muscle groups.

In adults the treatment is confined to re-educative exercises and to the application of simple splints such as cock up splints to control wrist and finger flexion and short leg irons with adjustments to the footwear to prevent drop-foot (Fig 71) In children treatment depends primarily on the mentality of the patient and ultimate success rests on the ability of the child to co-operate Where there is advanced degree of mental deficiency treatment of the physical disability is hopeless but where the mentality is fair much can be done to improve function The treatment involves re-education splintage and in some

cases operation Operation is usually contraindicated in children liable to convulsive seizures or suffering from incontinence of urine

Re-education —As in infantile paralysis re-education is the greatest single factor in treatment A short daily attendance at a hospital clinic for exercises is not sufficient An attempt should be made to encourage a daily routine and thus establish an ordered life Exercises therefore should be purposeful and interesting It is essential that the child have complete trust in the instructor and time spent in establishing confidence is valuable The best results are obtained where a member of the family has the time and interest to co-operate in the child s instruction so that the daily routine of fixed habit is ensured even in the home surroundings In mild cases gradual stretchings of contracted tendons are performed very slowly so as to allay fear and prevent muscle spasm The patient is encouraged to concentrate on assisting the efforts of passive stretching by the performance of some simple act such as building a picture block using a spoon or a brush and comb At night splints are applied to continue passive stretching during the hours of sleep In more difficult cases surgical measures supplement re-education and splintage by tenotomising tight structures or by the division of peripheral nerves so as to minimise their stimuli to the overacting muscle groups Drugs such as luminal chloral hydrate or the bromides are useful in the preliminary stages of treatment

Tenotomy and Stretching —In the upper limb the typical position in a severe case of spasticity is adduction at the shoulder flexion at the elbow pronation of the forearm and flexion of the wrist and fingers The usual procedure where re-education and passive stretchings are not proving effective is to manipulate the arm into full extension and supination at the elbow combined with dorsiflexion of the wrist and fingers This position is maintained in plaster for six weeks and then full corrective exercises begun removable splints made from plaster of Paris being discarded gradually as function improves

Tenotomy of the pronator radii teres is indicated where passive efforts to supinate the forearm are restricted by a fixed resistance A posterior incision is made 3 in long at the junction of the upper and middle third of the radius On retraction of the supinator longus the broad tendon of pronator teres is defined at this level and is divided Plaster of Paris is applied with the arm in full supination for eight weeks and exercises are begun as described previously

In the lower limb the position in advanced cases is one of flexion internal rotation and adduction of the hip flexion of the knee and plantar flexion of the foot If the deformity is confined to the tendo Achillis mainly with resultant equinus deformity it may be possible to stretch the tendon in a series of below knee plaster casts In the more severe cases where contraction is affecting the entire limb multiple tenotomy is usually necessary

Subcutaneous tenotomy often suffices The flexed hip is put on the stretch and the tight structures in the region of the anterior superior iliac spine divided As the hip extends further tight fascial bands appear and are divided by multiple tenotomy until full extension is obtained The adductor muscles are divided in a similar manner near

their origin from the pubic ramus The knee is stretched and where elongation of the biceps tendon is required this is performed by a small open incision to avoid injury to the underlying common peroneal nerve The tendo Achillis is finally stretched until the foot is at a right angle The limb is maintained in wide abduction external rotation and extension in either a plaster of Paris spica or a Jones abduction frame Exercises are begun in four weeks and the patient allowed up in a walking caliper in a further four weeks the latter being gradually discarded as functional control is established

Open tenotomy may be required in severe cases

Operation on Nerves.—Stöffel s operation (division or crush of peripheral nerves) is the only one practised and that uncommonly The operation is frequently combined with stretching or tenotomy of tight structures and in such cases it is difficult to decide the relative benefits of the two procedures

The *median nerve* may be exposed in the upper third of the forearm by a mid line incision The branches to pronator teres and to the wrist and finger flexors are identified by electrical stimulation and are either divided or crushed The wrist and fingers are maintained in extension for four weeks afterwards being exercised regularly throughout this period

The *obturator nerve* may be divided by either of two methods according as the lesion is bilateral or unilateral

In bilateral cases an incision is made in the suprapubic region the rectus muscles of the abdomen separated and the two nerves exposed at their entrance to the obturator foramina

In unilateral cases an incision is made on the inner aspect of the thigh centred over the origin of adductor longus This is divided, exposing the underlying anterior branch of obturator nerve which is also severed The posterior branch is now located as it emerges from the obturator foramen higher up and it also is divided

In both these procedures the limbs are maintained in corrected position for some four to six weeks being exercised throughout

The *tibial nerve* is exposed by a vertical mid line incision in the popliteal space and traced downwards between the medial and lateral head of the gastrocnemius muscle The branches to this muscle are divided and in severe cases the branch from the medial aspect passing to the dorsal portion of the soleus muscle may be cut also A plaster cast is maintained for six weeks with the foot at right angles and the knee in extension, weight-bearing being allowed after three weeks

CONTRACTURES

In the initial stages contractures may exist in soft tissues only but where the effect persists for long periods changes in bone and joint occur to accommodate the limb to the new mechanical position This results in fixed deformity Soft tissue contracture following on burns or extensive damage to skin from other causes is the province of plastic surgery but stretching of tight structures by suitable splintage is usually a necessary adjunct to any plastic procedure.

The methods at our disposal combine that of gradual traction moulding in a series of plaster of Paris splints and operative measures on soft tissues or bone These methods will be described and their commonest spheres of application indicated.

Correction by Traction—This method is used in relatively early cases of contracture especially of the hip or knee where the lesion is confined to the soft tissues and where there is no sound ankylosis present in related joints The muscles may be merely in a state of spasm to protect painful movement in a joint or they may have undergone adaptive shortening from prolonged faulty posture after such conditions as injury or mild infection Skin traction usually suffices and skeletal traction is rarely used For flexion deformity at the hip the traction may be obtained by weight and pulley or by attaching the skin

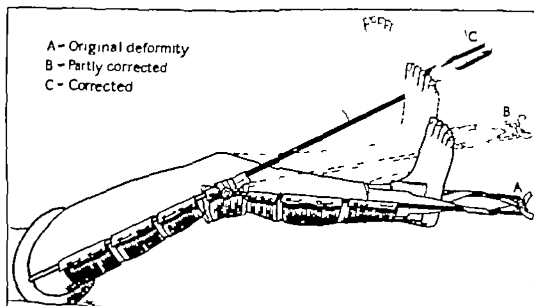


Fig –

Use of Thomas splint fitted with flexion piece for correction of flexion deformity of knee.

extension tapes to the bed rail and raising the foot of the bed so that the body weight is utilised

An alternative method is to use the Thomas abduction frame Here the patient's trunk and pelvis are securely held and the lower limbs fixed by skin extension to an adjustable leg piece By combined traction and abduction correction of deformity is obtained

Flexion deformity of the knee may be corrected by applying a Thomas bed splint suitably bent at the level of the knee to conform to the amount of flexion deformity The leg is attached to the lower end of the splint by the usual skin extension. A firm leather support is placed behind the head of the tibia and the splint gradually straightened over a period of several weeks It is important to keep the extension tight and to adjust the support behind the knee regularly otherwise the head of the tibia may luxate posteriorly and result in genu recurvatum

Correction in Plaster of Paris—This may be used in two ways either by applying a series of plaster casts at short regular intervals

and gradually correcting the deformity by manipulation on each occasion or by the method of *wedge plaster*

In the latter the limb is well padded and a plaster cast applied Thereafter a slit is made on the concave side of the plaster and into this a wedge of cork or wood is inserted and held in position by a further plaster of Paris bandage Larger wedges are inserted at intervals of a few days the correction being done slowly enough to prevent undue pain

Agnes Hunt's method is useful for correcting bilateral flexion deformity of the hip joints especially in cases of extensive infantile paralysis where conservation of all muscle power is desirable and tenotomy therefore inadvisable A plaster spica is applied with the hip joints in position of deformity One limb of the plaster is divided

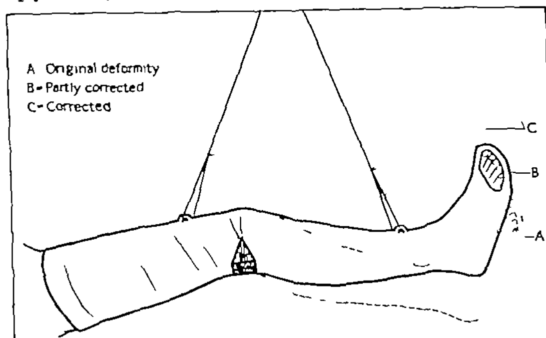


Fig 73

Wedge plaster for flexion deformity of knee

at the groin and bandaged to a Thomas bed splint which *is then* gradually lowered The process should occupy a period of weeks so as to cause minimal discomfort to the patient The flexors of the hip are thus gradually stretched the pelvis being fixed and prevented from tilting by the spica on the other leg When the free leg is straight the complete plaster is removed and a fresh spica applied with the corrected limb now enclosed in the straight position The procedure is then repeated for the other limb Care must be taken to avoid pressure sores during this method of treatment

Correction by Operation —Tendons may be divided subcutaneously by open operation Fascial strands or contracted joint capsule may be exposed and divided (fasciotomy and capsulotomy) or muscle attach ments may be separated and displaced (muscle slide operation)

For severe flexion contracture of the hip *Soutter's operation* which combines these procedures, may be used as an alternative to the Agnes

Hunt method of gradual correction An incision about 6 in. long is made along the anterior margin of the iliac crest and downwards in the line of the contracted tensor fasciæ latæ The fascia along the iliac crest is incised and the underlying muscles stripped from the ilium by a periosteal elevator as far as the anterior inferior iliac spine If manipulative correction of the deformity is still resisted the capsule of the hip joint is incised anteriorly and the contracted tendon of the iliopsoas elongated if necessary The prominent anterior superior spine of the ilium is now removed with bone forceps and the skin wound sutured A plaster spica or a Jones abduction frame is then applied *Osteotomy* may be required to correct deformity especially when due to fixed ankylosis resulting from destructive disease in a joint where it is inadvisable to disturb the process of healing

Operations of this type are most commonly indicated for con tracture at the hip or knee and are carried out along the lines described in the regional chapters

MANIPULATIVE SURGERY

Treatment by manipulation is a branch of surgery that has not been practised extensively by the profession although it has received increasing attention in recent years There has been a tendency to keep its application wrapped in mystery instead of explaining the principles of its application on a pathological and clinical basis Although manipulation is used to reduce a fracture or a dislocated joint it is proposed to confine discussion for the present purpose to the treatment of such disabilities in a joint as pain stiffness and deformity

In the first instance a detailed history radiological and clinical examination, are necessary where any of the foregoing complaints are made so as to eliminate cases unsuitable for manipulation This form of treatment is always contraindicated in the presence of active arthritis local infection or bony deformity while on the other hand, it is beneficial in the presence of maladjustments or simple adhesions. *Maladjustment* has been described as the seizing of a joint or its temporary locking in a position of strain It is seen where there is dislocation of a knee cartilage or in association with local muscle spasm as in acute spasmodic torticollis both of which can be cured by manipulation *Adhesions* which constitute the other group of cases, are formed as the result of organisation of a serous or hæmorrhagic exudate They may occur in a joint (intra-articular and inter articular) around a joint (peri-articular or extra-articular) or between a tendon and its sheath (extra articular) They are at first filmy and easily stretched but later pass through varying stages of elasticity till they finally become dense avascular bands of fibrous tissue This is the natural process of repair following trauma or infection and represents a necessary step in the cure of a disease condition or a temporary stage in the healing of injury In the former they must not be interfered with as movement may liberate the disease which has been shut off This is seen in tuberculous lesions or after acute infection in joints and is

also a feature of certain types of progressive arthritis where joint surfaces have been completely destroyed

It is possible clinically to differentiate the case of subacute arthritis from that of adhesions *Pain* is common to both but in arthritis it is present in all ranges of joint movement, whereas in adhesions it is present only in those ranges of movement which stretch the adhesions The former is an indication for rest and the latter for movement

Joint stiffness is common to arthritis and to cases of simple adhesions and each may benefit by manipulation The suitable case in arthritis is where the patient has a slight increased range of movement after active exercise and where the pain from such exercise is of short duration and disappears on rest In such instances it is better to carry out repeated manipulation at short intervals increasing the range of movement gradually than full manipulation at one sitting Where exercise however is followed by a pain which persists even during rest then permanent limitation of movement is certain and splintage in optimum position for later function is the treatment of choice

In traumatic cases or joint strain it is advisable to apply a compression bandage in the early stages to limit subsequent hæmorrhage and effusion into the joint Thereafter mild active exercise is encouraged the range of movement being gradually increased each day and the soft filmy adhesions stretched as they form At a later stage when the adhesions are firmer mild passive exercises may encourage movement but these must only supplement and never replace the patient s voluntary efforts

Where neglect of early treatment has occurred dense adhesions form and these avascular structures may be stretched by forcible manipulation.

There are certain basic rules to be observed in the practice of manipulative surgery although the procedure for each joint has additional features peculiar to itself

1 Manipulation should be performed under general anæsthesia to ensure complete muscular relaxation, but as it is desirable to obtain early co-operation of the patient the anæsthetic should be gas and oxygen with minimal ether or intravenous medication

2 It is advisable to employ short leverage so that shafts of long bones may not be exposed to undue force and possible fracture.

3 Limbs which have been splinted for many weeks have undergone some decalcification of bone and are unsuitable for forced manipulation

4 All manipulation must be followed by active exercises so that the patient s own muscular effort controls the new range of movement gained.

5 The joint is put through its full range of movement once only at each treatment Repeated stretchings serve no useful purpose and merely cause reactionary effusion and hæmorrhage

Where fixation is due to a single dense adhesion there is an audible snap and thereafter the full range of movement is restored but where

there is a gradual yielding with a series of crunching sounds due to multiple adhesions, the after treatment is more prolonged

Experience shows that certain joints respond to manipulative treatment better than others For example the shoulder knee foot, and spine give good results in properly selected cases whereas the fingers and elbow with few exceptions respond better to concentrated active exercise rather than forced movement

Manipulative Procedures—*Shoulder*—The usual complaint in these cases is loss of abduction and rotation Voluntary attempts to elevate the arm are accomplished by scapular movements rather than by movement at the shoulder joint proper

The patient is placed in dorsal decubitus with the affected shoulder over the edge of the table An assistant fixes the scapula the shoulder is fully rotated and then abducted with a clenched fist in the patient's axilla to prevent dislocation of the shoulder The scapula is now released

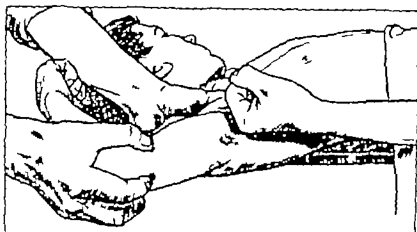


Fig 74
Manipulation of the shoulder

and the arm raised till it lies alongside the patient's head In this position full external rotation is obtained by placing the patient's hand behind his head and the arm is then pressed backwards to stretch the anterior part of the capsule The arm is now lowered and internally rotated till the flexed forearm can be carried behind the back. Thereafter circumduction is carried out and traction is made finally in the long axis of the arm

In disability of long standing it is advisable to place the arm on a Littler-Jones abduction splint after manipulation and to obtain voluntary control of abduction and external rotation before leaving the arm completely free

Knee—The method of reduction of a dislocated semilunar cartilage is dealt with elsewhere and only routine manipulation for adhesions will be described If the patella is adherent it is liable to fracture during manipulation.

With the patient in the dorsal decubitus the patella therefore is mobilised by lateral and medial pressure The knee then is flexed till the heel touches the buttock. An assistant steadies the patient's thigh

and the knee is rotated fully internally and externally in this position The operator now places his forearm in the popliteal space and forces flexion over this to push the tibia forwards With the knee still flexed he now hyperextends the hip to stretch the quadriceps and then gradually extends the knee carrying out rotatory movements *throughout until full extension is obtained*

Foot —The manipulative procedure is described under treatment of flat-foot (p 357)

Spine.—Backache is a common complaint and may be due to strain from sudden violence or to gradually repeated minor traumata It is often associated with adhesions in the paravertebral soft tissues (lumbago) and with pain referred *along the distribution of the sciatic* nerve (sciatica) The well known syndrome of sacro-sciatic-scoliosis is a postural deformity which occasionally yields to manipulation alone but is better treated in many cases by gentle manipulative correction of the deformity followed by two to three months fixation in ambulatory plaster of Paris spica or jacket The following procedure should be carried out as a routine in all spinal manipulation —

(a) *Stretching the Hamstring Muscles* —The patient lies in the dorsal decubitus and each lower limb in turn is flexed at the hip to at least a right angle with the knee held in extension an assistant meanwhile holding the free leg firmly to the table

(b) *Flexion* —Both lower limbs are raised by the surgeon placing his right arm under the patient s flexed knees and then flexing the patient s thighs on his trunk. This movement is con tinued till the buttocks are raised from the table thus ensuring full flexion of the spine

(c) *Rotation* —The patient is now turned on his right side with his back to the surgeon The right leg *is maintained in extension* whilst the left knee and hip are flexed to a right angle Rota tion of the spine is carried out by quickly and forcibly pressing the *left shoulder* backwards with the right hand and the left buttock forwards with the left hand The procedure is then repeated for the right side

(d) *Extension* —With the patient lying face downwards the lower limbs are hyperextended by the operator placing his right arm under the patient s thighs proximal to the knees whilst he exerts counter pressure in the lumbar spine with his left hand.

(e) *Lateral Flexion* —With the patient either in the prone or supine position lateral flexion is carried out by carrying the limbs and pelvis to each side in turn whilst an assistant exerts counter pressure by fixing the trunk.

A M

CHAPTER XIV

FRACTURES

PRINCIPLES OF FRACTURE TREATMENT

THE aim of fracture treatment is to restore the injured part to full anatomical normality and to full *functional activity* the latter being the more important The principles of fracture treatment are —

1 *Reduction* —Displacement of the broken bone must be corrected and the correction verified by X ray examination
2 *Immobilisation* —The injured part must be immobilised efficiently and continuously till union of the fracture is fully established
3 *Functional activity* —During the period of healing free active use of all non immobilised joints and muscles of the injured limb must be carried out from the very beginning of treatment

It is the duty of the surgeon to see that all these *principles* are scrupulously and conscientiously observed throughout the whole period of treatment and this will entail on his part constant supervision and care *Patients suffering from fractures must be seen* and examined at regular intervals often daily especially in the early part of their treatment and rarely at intervals of more than one or two weeks *so that the surgeon can satisfy himself that splints,* plasters or other appliances remain effective and so that he can observe and if possible prevent the onset of complications

Such is the *necessity for continuous care and follow up* that modern practice tends strongly in the direction of the segregation of fracture cases in special departments where continuity of treatment close supervision *regular follow up examination and unity of control* can be achieved

First-aid Treatment of Fractures —The aims of first-aid treatment are (1) *to prevent further damage* (2) to immobilise the fracture sufficiently to permit transport to hospital (3) to treat shock

Temporary splints should be applied before any attempt is made *to move the patient* and should be of sufficient length to control the joint above and the joint below the site of fracture This will prevent further damage being done by the broken bone ends and possibly *prevent* a simple fracture being made compound Once splints have been applied, the patient should be moved with all care to a place of shelter warmth applied, hot drinks administered and his transference to hospital arranged with all dispatch

Reduction of the Fracture—Accurate diagnosis of the injury is the first essential in treating it Following a careful clinical examination radiography should always be carried out and an exact estimate of the injury arrived at Reduction of the fracture should then be undertaken without delay—all recent fractures are cases of emergency—unless the general condition of the patient contraindicates it It is well to remember however that symptoms of shock often disappear as soon as the fracture is reduced and immobilised and that immediate reduction and fixation is often the best treatment in the patient who is mildly shocked

The ideal time for reduction is within an hour or two of the injury—hence the necessity for urgency and speed in fracture cases Swelling and œdema about the site of fracture appear rapidly and may in the space of a few hours become so gross as to necessitate delaying reduction until the swelling has subsided—a process that may be expedited by elevating the part

While the aim of the surgeon is to restore the broken fragments to a position of anatomical normality it is well to realise that full restoration of function can sometimes be achieved without attaining this ideal Certain criteria must however be satisfied (1) Angulation must be corrected the fragments being placed in proper alignment This is of particular importance in the weight bearing lower extremity where angulation leads to abnormal strains on joints and ligaments and to the development of osteo arthritis (2) Overriding of the fragments must be corrected and the bone restored to its full length—again a point of primary importance in the lower limb (3) In fractures involving the articular surface of a bone exact anatomical reposition should be aimed at

Anæsthesia.—Anæsthesia is almost essential for the reduction of a fracture with displacement and must be sufficiently deep to overcome muscle spasm which may prevent reduction or cause redisplacement Local or inhalation anæsthetics are most commonly used but intravenous and (in the lower limb) spinal anæsthetics are sometimes preferred

Local Anæsthesia may be induced by injecting 20 to 60 c c of 2 per cent procaine directly into the hæmatoma round the fracture This abolishes pain at the site of the fracture and the reflex muscular spasm which is secondary to the pain then disappears With full aseptic precautions a needle is passed through the skin over the site of fracture and into the hæmatoma Evidence that this has been accomplished is obtained by aspirating some of the hæmatoma fluid into the syringe and the anæsthetic is then injected. Anæsthesia is likely to be unsatisfactory if the hæmatoma cannot be found a difficulty which will be met with particularly in fractures with little displacement *e.g* a slightly displaced and impacted Colles fracture

Methods of Reducing the Fracture—Before attempting to correct the displacement the limb should be placed in such a position that reduction will not be hampered by the tension of taut muscles For example in fracture of the leg the knee should be flexed to a right angle and the foot plantiflexed to relax the gastrocnemius muscle

1 *Reduction by Traction* —This method is most valuable in fracture of the long bones When possible the limb should be so arranged that traction is maintained without intermission until the fracture has been immobilised Such traction should be steady and prolonged and the method may be described as it is applied to a case of fracture of both bones of the forearm

With the shoulder in 90° abduction a loop of broad webbing is passed round the arm (suitably protected by a square of cotton wool) and fixed to a hook on the wall The assistant then grasps the patient's thumb in one hand and the first three fingers in the other and leaning back with arms straight exerts a steady pull on the fractured forearm The elbow is kept at a right angle and the position of the forearm as regards pronation supination is adjusted as required When traction has been maintained in this way for some minutes reduction will probably have occurred and may be confirmed by palpation and measurement Traction being still maintained the surgeon can now apply a posterior plaster splint from the knuckles to the upper arm An anterior splint may then be applied and circular plaster bandages to complete the cast

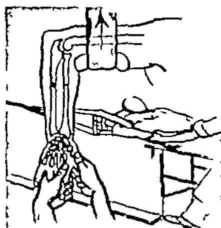


FIG 73

Reduction of a fracture of long bones by manual traction in axis of limb. Method applied to fracture of both bones of forearm.

In fracture of the larger bones more powerful traction may be needed It may be applied to produce immediate correction of the displacement or gradual reduction The former is exemplified in the use of Böhler's screw traction apparatus for fracture of the leg bones in which powerful traction is applied to a wire or pin transfixing the calcaneus the latter is exemplified in the weight-and pulley method of reducing fracture of the femur Surgeons differ as to the relative merits of the two methods Gradual reduction is safer and simpler, is usually quite effective and on the whole is preferable

Similarly there is a divergence of views as to the merits of skeletal as opposed to skin traction Skeletal traction allows the use of powerful extension and achieves rapid reduction but the method is open to the criticisms that infection may enter the bone along the track of the pin—an accident that though rare may lead to disastrous results—that the wire may cut right through the bone and that with this more powerful method there is greater danger of overextension, and as a result non union Skin traction has the great advantage of absolute safety and when skilfully used especially as a fixed traction with a Thomas splint can be completely effective and satisfactory even in bad cases of fractured femur

2 *Reduction by Manipulation* —Displacement of the broken fragments may also be corrected by manipulation or by a combination of manipulation and traction Jones method of reducing a Colles

fracture is one of the best known and most useful manipulations, while the methods commonly used for the reduction of a supracondylar fracture of the humerus and of a Pott's fracture are further examples of this method of reduction

When the fracture is impacted disimpaction may be necessary and is accomplished by manipulation or by steady traction

A special example of the method of manipulation is the method of wedging a plaster case to correct an angular deformity The plaster is cut through round rather more than one half of its circumference on the concave side of the deformity at the exact level of the fracture The deformity is then corrected by manipulation and the gap in the plaster wedged open by a small block of wood Further correction can be obtained, if necessary by using a larger or smaller wedge and when good alignment is obtained the plaster case is reconstituted by the application of a few plaster bandages

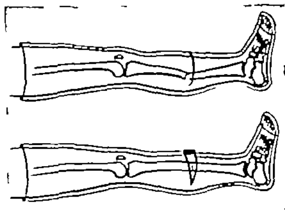


FIG 76

Method of wedging a plaster case to correct angular deformity in fracture of a long bone

3 *Reduction by Operation* —Operative reduction is required in certain special types of fracture unsuitable for closed reduction in any fracture where repeated attempts at closed reduction have failed and in fractures where internal fixation is necessary

Immobilisation of Fractures.—The principle that a fractured bone must be *adequately immobilised until union is complete* cannot be too strongly stressed Movement at the site of fracture interferes with normal healing and may even lead to cessation of the healing process and retrogression Of all movements which may occur at the site of fracture rotatory and shearing movements are particularly harmful and must be wholly prevented if at all possible

Methods of Immobilisation —The classical method of immobilising fractures was by the use of external splints of wood or metal A great variety of such splints was available specially designed for the treatment of different fractures, but the majority of these are to-day obsolete Their place has been taken by plaster of Paris by traction apparatus and in certain well-defined cases by internal fixation by nails pins, plates or bone grafts

Immobilisation by Plaster of Paris —Plaster of Paris gives the best fixation in the distal parts of the limb where the bones are less heavily clothed with muscles as in fractures of the wrist and forearm and of the foot ankle and leg It is much less efficient in situations where it cannot be accurately moulded to the bones as in fractures of the shaft of the femur It is not suitable at least for the primary treatment for oblique fractures of the long bones which have a marked tendency to override

A good plaster technique and skilled assistance are necessary to obtain the best results in the use of plaster and the surgeon who makes himself familiar with his medium and pays attention to details will be rewarded by the efficiency of the splintage and by the comfort of his patients

Plaster bandages may be made up in hospital or be bought ready made The former are much cheaper and are suitable for the making of large cases and spicas but set more slowly The latter contain more plaster give lighter cases and with their quick setting quality are excellent for fractures which have to be held in position until the plaster sets.

Plaster bandages may be applied in circular fashion to form a case which may be reinforced by plaster slabs or the slabs may be applied first and held in place by plaster bandages Alternatively, slabs applied directly to the skin may be used as splints held in place by cotton or muslin bandages

Plaster bandages may be applied (*a*) directly on to the skin, (*b*) over a layer of stockinet (*c*) over a layer of padding of felt or cotton wool, the padding either covering the whole area or being applied only over parts liable to pressure for example bony prominences like the anterior superior iliac spines the sacrum and the lumbar spine

Before applying the plaster the part must be arranged in the position in which it is to be immobilised and must be held in that position without movement throughout the application and setting It is dangerous to change the position of the limb once the application of plaster has begun

If applied circularly to the limb without padding it is most important that the bandage should be made to fit the limb as accurately as does a silk stocking Every turn must be most carefully moulded over bony prominences and into hollows and the greatest care must be exercised to avoid drawing one edge of the bandage too tight in an endeavour to get an accurate fit rather should the bandage be looped or folded back on itself as often as is necessary Once the whole area to be included in the case has been covered in this way the case may be reinforced on those aspects which require strengthening by the application of plaster slabs

An alternative way of making a reinforced plaster case is to apply plaster slabs to the limb first and over them to apply circular bandages If this technique is followed the slabs should be bandaged evenly on to the limb with wet 3 in cotton bandages This ensures accurate fitting and holds the slabs in position until they are set This method is commonly used, for example in Pott's fracture

Plaster splints may also be used alone without the addition of circular bandages If so they are applied as described above and moulded and held in position with cotton bandages or simply moulded to the part and later fixed on with an ordinary bandage or preferably with adhesive strapping

If stockinet is used it is drawn over the part in either single or double layer and the plaster applied by one or other method over it. It is usually unnecessary to use stockinet on the limbs but its use on the trunk increases the patient's comfort.

When a complete layer of padding is considered necessary, and it usually is in plasters applied immediately after an operation and in plasters which enclose the trunk special cotton wool bandages may be used or bandages made from ordinary cotton wool of half the usual thickness and in appropriate widths Felt is a useful padding material particularly for sites like the sacrum and spine and for bony prominences like the anterior superior iliac spine or the iliac crest Such protective pads may be fixed to the stockinet by one or two points of stitch or a special felt with adhesive surface may be used and fixed directly to the skin

While the plaster is setting the edges should be trimmed in such a way as not to leave a sharp edge next the skin and so as to ensure that movement of neighbouring joints is not restricted

If a plaster case is applied too tightly especially when applied after a recent injury where swelling is likely to occur, it may embarrass the circulation of the limb and possibly produce gangrene The fingers or toes of a limb so encased must always be left visible so that the state of the circulation may be watched *It is a sound rule in all such cases to split the plaster as soon as it is completed* This can be done most easily if a flexible steel wire is left in contact with the skin under the plaster and held tight to bear against the edge of the scalpel used for cutting the plaster Elevation of the limb is an additional safeguard against circulatory embarrassment Plasters take a con siderable time to dry and great care must be taken in transporting the patient back to bed and in arranging him in bed to prevent the plaster becoming bent or distorted or indented A simple precaution for example is never to allow the heel of a leg plaster to rest on the table or bed till the plaster is quite dry but to support it clear of the bed by placing a roller bandage under the tendo Achillis If the plaster becomes indented over the heel a pressure sore is liable to occur To hasten the drying of a plaster the bed clothes should be supported on a cage to allow free passage of air

For removing plasters the best instrument is a plaster shears The plaster should be cut through on opposite sides bivalved so that the upper half can be lifted off like a lid The two halves can be bandaged together again as a temporary measure and this will hold the limb satisfactorily till a new plaster can be applied should this be necessary An alternative method of removing a plaster case is to soak the whole plaster in water when it may be cut with a knife

Immobilisation by Extension —Immobilisation by extension finds its greatest sphere of usefulness in the treatment of fracture of the shaft of the femur but is also used in some fractures of the phalanges and metacarpals of the forearm bones and the humerus and particu larly in oblique fractures of the shafts of the leg bones Traction may be applied to the limb by fixed extension or by balanced extension by weights over pulleys In *fixed extension* the extension tapes or other forms of traction apparatus are tied to the distal end of a splint which supports the limb and whose proximal end bears against a bony prominence as a fixed point By keeping the extension tapes constantly tight steady traction is maintained on the fractured

bone In *balanced extension* by weights and pulleys the traction force is conveyed by a cord over pulleys to the adhesive tapes or other traction apparatus the limb being supported in some form of splint or sling By raising the foot of the bed the patient's body weight is made to act as the counter-extension The advantages of fixed traction in fracture of the shaft of the femur are that it gives better immobilisation especially if local splints are applied as well and it requires no apparatus except a Thomas splint It is the ideal form of fixation for transport an important consideration in war time The disadvantages are that a Thomas' splint of suitable size is not always available and that considerable discomfort and even pressure sores may be caused by the pressure of the ring of the splint on the perineum or groin These difficulties may be got over by skilled nursing and constant attention to the skin at the pressure points especially during the first few days or by adding to the fixed traction an element of balanced traction by attaching the splint to the foot of the bed which is raised on blocks so that the patient's weight pulls him slightly away from the ring of the splint and the irksome pressure is thus appreciably diminished

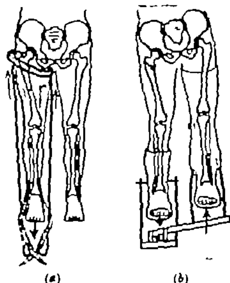


Fig 7

Two methods of fixed traction :—
(a) Thomas splint and skin traction in fracture of shaft of femur
(b) Well leg traction (Roger Anderson splint) in intertrochanteric fracture

Both these methods of extension require careful attention to detail constant supervision and skilled nursing if the best results are to be obtained and the surgeon who uses them must take pains to understand fully the method he employs and to supervise frequently the apparatus he uses

Immobilisation by Internal Fixation — Internal fixation by screws pins bone grafts, and other devices involves open operation with its attendant risks and is only justifiable when other methods of fixation have failed or are known to be unsuitable for the special type of fracture present The technique and methods of internal fixation are described on p 241

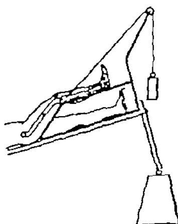


Fig 78

Method of balanced traction in fracture of shaft of femur—skeletal traction on a Böhler Braun splint.

Radiological Control throughout Treatment.—Before leaving this subject it is well to stress the importance of X ray control of the various steps in treatment In some cases the position of the fragments

may be checked by X ray examination immediately after reduction and before the splint is applied In *all* cases the position should be checked by X ray after the plaster case or splint has been applied or after the extension apparatus has been fitted up Furthermore after every adjustment especially during the early stages of treatment the position must be controlled by X ray examination If this is omitted a fracture may be allowed to heal in malposition with possibly tragic results

Functional Activity during Immobilisation.—At different times in the past either the absolute fixation of the fracture or the early active use of the limb has been stressed as the cardinal point in the treatment of fractures To-day the complete immobilisation of the fracture *combined with* the greatest possible use of the limb during the period *of immobilisation is the basis of fracture treatment* While the joints nearest to the fracture must be immobilised, every other joint in the affected limb should from the beginning of treatment be exercised frequently and *through its full range* Such active movement also prevents muscle atrophy prevents adhesions in tendon sheaths and fascial planes ensures an active and efficient circulation and keeps the whole limb in a state of functional activity against the time when immobilisation can be dispensed with

The importance of active as opposed to passive movement cannot be too strongly emphasised Passive movement is not only much less useful but may be positively harmful and its use as a therapeutic measure in the treatment of stiff joints in a fractured limb is to be condemned It is also of great importance to insist on a *full range* of active movement in non immobilised joints from the very outset Movement through a limited range will not prevent the formation of adhesions which may seriously limit the movements of the joint later

The importance of active movement must be explained fully to the patient who may otherwise refrain from exercises in the belief that they will cause pain and disturb the fragments

The Restoration of Function after Union of the Fracture—Once bony union of the fracture has occurred and the splint has been discarded active movement continues to be the most important factor in promoting full functional recovery Passive movement at this stage must still be condemned as potentially harmful. Physiotherapy can now be used with benefit and heat massage and faradism may all be of value Finally as muscle power develops and joint movements are restored active exercises and games of increasing severity are prescribed until the ultimate goal of complete restoration of function is attained

In fractures of the lower limb œdema may be a troublesome complication It develops as soon as the patient begins to move about after removal of the plaster and is due to a certain loss of vasomotor tone and to the loss of the external support supplied by the plaster When developed it hinders recovery by causing discomfort and joint stiffness It is best treated by prevention and this is readily done by enclosing the limb immediately after removing the plaster, in a

zinc-gelatine or *elastic adhesive bandage* Such a bandage is particularly useful after Pott s fracture and fractures of both bones of the leg It should usually be worn for several weeks

In the last stages of treatment there may be a place for forcible passive movement or manipulation This may be carried out for residual loss of movement usually due to extra articular adhesions but it must be carefully controlled and never done until many weeks *after union has become firm lest the bone be re fractured*

THE TREATMENT OF COMPOUND AND INFECTED FRACTURES

Compound Fractures.—The primary consideration in treating a compound fracture is to prevent infection This is achieved by the *same method as is used in the treatment of any recent wound namely* by careful cleansing and excision of the wound By this is meant (1) free exposure of the whole wound enlarging the skin wound and the wound in the deep fascia if necessary (2) excision of the skin margins of the wound and of the walls of the wound cavity this excision including particularly all damaged devitalised or contaminated tissues Contaminated bone surfaces must be shaved off and *any fragments of bone which have lost all soft tissue connection should* be removed Bone fragments which still have a periosteal attachment must be left

In some cases it is now possible to close the wound suturing the skin only *Immediate closure* or *primary suture* should only be performed (*a*) when the wound is recent *i e* not more than six to eight hours old (*b*) when a satisfactory excision has been done (*c*) when *the wound has not been severely lacerated or contaminated* (*d*) when the skin edges can be brought together without tension If these criteria cannot be satisfied or if there is any doubt as to the wisdom of stitching the wound then it is far better to leave it unstitched and packed widely open with vaseline gauze

In all cases where there appears to be a risk of infection a prophylactic course of penicillin should be started immediately

Where a wound has been left open the possibility of carrying out a *delayed primary suture* must be kept in mind In the absence of serious wound infection such delayed suture should when possible be done three or four days after the initial treatment If delayed primary suture has not been feasible *secondary suture or skin grafting* should be resorted to as soon as conditions permit

The second part of the treatment the immobilisation of the fracture is no less important It is as great a mistake to treat the wound at the expense of the fracture as *vice versa* A method of fixation suitable to the particular fracture must therefore be adopted and the treatment proceeded with as for a simple fracture

The *closed method* of treatment by fixation in a complete plaster case has much to recommend it for the fracture is efficiently immobilised, the injured soft tissues heal more rapidly and infection is less apt to develop Its disadvantages are that such virulent infections

as gas gangrene may progress unobserved, and that if the wound has been unsutured the discharge irritates the skin and its smell soon becomes offensive The risk of gas gangrene is small if the primary treatment has been thorough and can be reduced still further by the use of penicillin and/or sulphonamide

Generally the fractured limb should be enveloped in a complete plaster case If the patient is to be under continuous observation a skin tight plaster may be used though preferably it should be split immediately If however as happens often in war casualties the patient is to be transferred to a base hospital a padded plaster case is preferable

After the application of the plaster a moderate rise of temperature for forty-eight hours or so may be ignored but any more serious pyrexia or any pain in the limb is an indication for exposing the wound by cutting the plaster Other indications are swelling of the distal extremity of the limb an increase of pulse rate or the appearance of enlarged glands in the axilla or groin Apart from the onset of infection the plaster may need to be changed if it becomes softened by wound discharges or if the smell becomes objectionable In such cases a fresh plaster may be applied after cleansing and possibly suturing or skin grafting the wound care being taken not to disturb the fracture

Infected Fractures.—Under this heading are included compound fractures in which infection has already become established The dictum that the treatment of the fracture must not be neglected for the treatment of the wound applies here also Indeed one of the important points in the treatment of the infection is the immobilisation of the fracture For the rest the guiding principles are exposure of the wound in its entirety by free incisions removal of devitalised tissue sequestra or foreign bodies and careful packing of the wound so that every pocket and cavity has free drainage to the surface If necessary rubber tubes or rubber dam drains may be inserted and brought out through the packing The fracture is then immobilised by the application of plaster or splinting and penicillin therapy may be instituted

THE TREATMENT OF SOME COMPLICATIONS OF FRACTURES

The following complications of fractures occur with sufficient frequency to warrant some mention of their treatment —

1 Joint complications such as adhesions ankylosis and osteo arthritis
2 Vascular complications such as aneurysm gangrene and Volkmann s ischaemic contracture
3 Nerve injuries
4 Mal union delayed union and non union

Joint Complications.—Stiffness due to adhesions within or around a joint is a common complication even though the joint is not directly involved in the fracture To a large extent it can be prevented by

insisting upon active movement during the whole period of immobilisation Later treatment when the plaster or splint has been removed, consists mainly of active exercises though various forms of physio therapy such as diathermy and infra red radiation are also of value and occasionally manipulation may be advised

Particular care is necessary when the fracture involves a joint In such cases every effort should be made to procure anatomical reposition of the fragments so as to reconstitute the articular surface otherwise some loss of movement will result and osteo-arthritis will develop This applies particularly to the weight bearing joints of the lower extremity If the late symptoms are of minor degree palliative treatment by physiotherapy may be all that is necessary If however the symptoms are more severe and incapacitating more drastic treat ment may be necessary In the lower limb arthrodesis may be advisable, for example of the ankle joint following a mal united Pott's fracture, or of the subtaloid joint following a crush fracture of the calcaneus In the upper limb where mobility is the main consideration the opposite type of treatment may be required for example arthroplasty of an elbow joint which has become ankylosed in bad position.

Vascular Complications.—Large blood vessels may be damaged by the force which has produced the fracture or by the sharp bone ends Damage to the main arteries is more serious than damage to the corresponding veins. In the latter case persistent swelling of the limb may ensue while in the former the more serious conditions of traumatic aneurysm gangrene or ischæmic contracture may result. Traumatic aneurysm may require treatment by proximal and distal ligature or possibly by repair of the vessel while the complete division of the main vessel of the limb may necessitate amputation

Ischæmic contracture is seen in its most massive and typical form following fracture in the region of the elbow especially supracondylar fracture and following fracture of the tibia and fibula in the upper third It is described on p 200

Nerve Injuries—Certain simple fractures are liable to be complicated by injuries to main nerves the commonest examples being injury to the radial nerve in fractures of the shaft of the humerus to the median nerve in supracondylar fracture and to the ulnar nerve in fracture of the medial epicondyle of the humerus Nerve injury as a late complication of fracture is exemplified by the delayed ulnar palsy caused by cubitus valgus deformity due to an old fracture of the lateral condyle of the humerus. The treatment is described on p 104

Mal union, Delayed Union, and Non union.—The treatment of non union and mal union of fractures is almost invariably operative and will be described later

Delayed union in the absence of any complications which may be the cause of the delay in healing requires no other treatment than further immobilisation provided the alignment and position of the fragments are satisfactory If angulation or other malposition is present operative treatment may be necessary If infection is present sequestra may have to be removed, drainage improved and the closed plaster technique employed

THE OPERATIVE TREATMENT OF FRACTURES

For recent fractures non-operative methods suffice in the great majority of cases the frequent employment of open operation is a reflection on the surgeon s skill in the use of simpler methods Open operation carries certain disadvantages and dangers It exposes the patient to the risk of accidental infection—a small risk with good technique but never to be disregarded it may delay the process of union and it leaves a scar which may involve the muscles binding them to the bone and limiting the movements of the limb

In special types of recent fracture however operation must be performed either to effect accurate reduction or to secure immobilisation Operation is also indicated for certain complicated fractures and for mal union or non union

The indications for operation are as follows —

1 To reduce a fracture where non-operative methods have failed or where by reason of the special character of the fracture they are likely to fail for example in fracture of the lateral condyle or medial epicondyle of the humerus In such cases fixation of the fracture may or may not be carried out at the same time
2 For the double purpose of reduction and fixation as in fracture of the patella and olecranon with wide separation of the fragments
3 Where there is difficulty in immobilising the fracture for example in fracture of the narrow part of the neck of the femur Here fixation by the Smith Petersen nail is the best form of treatment at the present time
4 Where the fracture involves a joint and operation is required to remove a small detached portion of the articular surface or the whole articular extremity of the bone when this has been hopelessly comminuted, for example in comminuted fracture of the head of the radius
5 Where the fracture is complicated by injury to a nerve or vessel.
6 For mal union or non union

Operative Technique.—Since wound infection must be avoided at any cost open operation for fractures must be performed only if a scrupulous aseptic technique can be followed.

The preparation of the skin must be thorough. The entire limb should be shaved thoroughly cleansed, and swabbed with antiseptic two days before operation and the antiseptic reapplied on the following day If the limb has been in plaster and the skin is dry and scaly even more thorough preparation is required all scales must be removed by soap and water spirit and ether and the skin restored to a healthy condition before operation Lastly in late operations where the fracture was originally compound and infected, the risk of lighting up a latent infection will be greatly diminished by administering penicillin for some days before and after the operation

At the operation the ideal to be aimed at is the so called no

touch' technique By this is meant that the fingers of the surgeon and his assistants must never touch the wound and that the business end of all instruments used in the operation as well as needles and suture materials, must never be handled by any member of the operating team Such an ideal seems at first sight impossible of achievement but by constant care and practice on the part of all members of the team it can be done

A similar high standard of asepsis must be maintained in all other directions Careful and complete sterilisation of instruments meticu

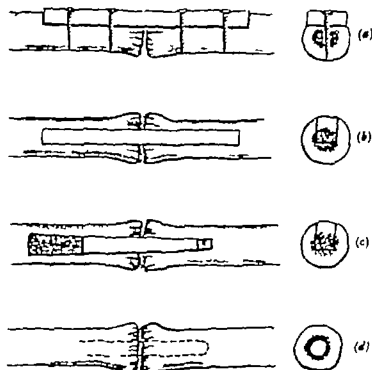


FIG 70

Different methods of bone grafting for fracture :—
(a) Onlay graft fixed by vitallium screws.
(b) Inlay graft—graft taken from another bone
(c) Sliding inlay graft.
(d) Intramedullary peg graft.

lous care in scrubbing up for operation and complete exclusion of the skin in the region of operation are all essential

When operating on a fracture adequate access must be obtained to expose the bone for 2 or 3 in above and below the fracture The bone ends are freed and freshened and the displacement is corrected by manipulation or traction The use of an orthopædic table or other special traction apparatus may facilitate this procedure When reduced the fragments are held in *special bone holding forceps while fixation by* plate or graft or pin is effected Care should be taken not to elevate the periosteum more than necessary and to suture it in place again whenever possible

After operation whatever method of internal fixation has been adopted a plaster cast or efficient external splintage must be provided

and maintained until union is complete, except in such special instances as fracture of the femoral neck where early movement may be desirable

Methods of Internal Fixation—*Bone Grafts*—Autogenous bone grafts are the most satisfactory internal splints and should be used whenever possible in preference to foreign materials

Autogenous grafts are conveniently obtained either from the bone at the site of the fracture or from the subcutaneous surface of the tibia

Intramedullary Grafts peg-shaped grafts driven into the marrow cavity across the fracture line are sometimes used but are not con sidered satisfactory *Onlay Grafts* are straight bars of bone placed across the fracture line one third of the circumference of the bone being excised from each fragment to leave a flat surface of raw bone of suitable length to which the graft is firmly fixed by means of bone pegs or vitallium screws The *Inlay Graft* is the method of choice in the tibia Here a gutter is cut with a twin bladed circular motor saw extending for an equal distance on either side of the line of fracture and is fitted with an inlay of bone removed from another site usually the subcutaneous surface of the tibia The fit should be accurate and tight to preclude the necessity for fixing the inlay in place Alter natively the *sliding inlay* may be used in which the segment of bone removed from one fragment is shifted down the gutter in the other fragment until it bridges the fracture line For this purpose a single-bladed saw should be used and the two saw cuts made to converge slightly so that the inlay can be wedged tightly in place

Metal Plates Screws Bands or Wires—Formerly these materials were in common use For transverse fractures of the long bones perforated plates of different sizes were fixed in place by metal screws introduced into holes drilled in the bone and tapped to receive them For oblique fractures Parham s flat metal bands were used to encircle the bone while for many other types of fracture silver or aluminium bronze wires inserted through drill holes were used to control the fragments

These materials were all open to the criticism that they sometimes caused atrophy of the underlying bone and thus impaired the process of union while the screws gradually became loose and often a subse quent operation was required for their removal Consequently plating of fractures and similar methods of fixation fell into dis use Recently however these disabilities have been overcome by the use of stainless steel or vitallium which produce little or no reaction and in the absence of infection may be left in place indefinitely As a result there is now a tendency to revert to these methods of fixa tion in cases in which the fracture cannot be properly reduced and immobilised by non-operative methods The Smith Petersen pin used for fracture of the femoral neck is an outstanding example and it seems probable that similar methods will receive a wider application in the future



FIG 80

Fixation of an oblique fracture by a transfixion screw

THE TREATMENT OF NON UNION

Established non union can only be successfully treated by operation The *essential purpose of any operation designed to promote*

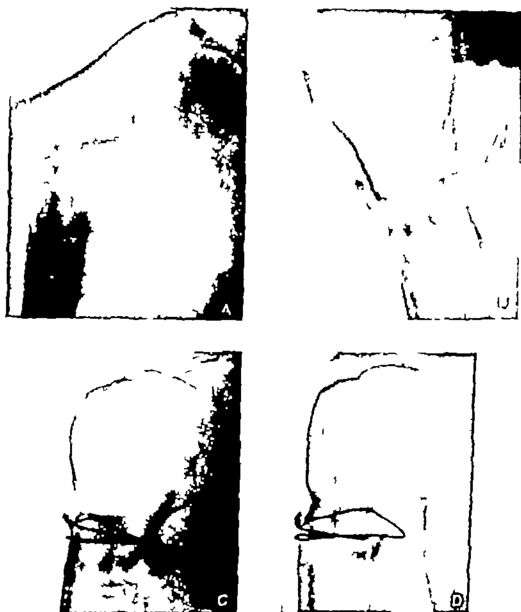


Fig 81

Severe compound comminuted fracture of upper end of shaft of humerus.

(a) Condition on admission

(b) After seven months immobilisation—established non union

(c) Step-cut operation performed.

(d) Completely healed in good position and with good functional result.

healing in a case of non union is to produce revascularisation of the sclerosed bone ends to reproduce in fact the conditions which are present in a recent fracture In addition by bone graft or otherwise

internal fixation of the fracture may at the same time be achieved Sometimes it is possible simply to freshen the ends of the fragments by excising the sclerotic bone and scar tissue while occasionally the step-cut operation can be used in which a step half the thickness of the bone is removed from opposite sides of the two fragments to bring healthy bone surfaces in contact Since this procedure leads to shortening of the bone it is only applicable to the humerus

In the great majority of cases however the treatment of non union should be by bone drilling or bone grafting

Bone Drilling —This is the simplest method of dealing with non union It has the advantage that full exposure of the fracture is not necessary but is only suitable for cases where the bone ends are in apposition and within easy access from the surface The skin is prepared as for any bone operation Using an electric drill and wires 1 5 to 2 mm thick multiple drill holes are made obliquely through the sclerosed bone ends, the drill being passed through two or more skin punctures made a few centimetres above and below the site of fracture The number of drill holes necessary will vary from 10 to 30 or more according to the size of the bone



FIG 82

Method of bone drilling for delayed union with sclerosed bone ends.

Bone Grafting —This is the method of choice in most cases The inlay graft and the onlay graft are the most efficient In cutting the bone ends to receive the graft the sclerosed bone is laid widely open and accurate fitting and firm fixation of the graft provide good internal splinting two most important points in any operation for non union These methods are widely used for non union of the tibia of the forearm bones and less frequently of the femur

FRACTURES AND DISLOCATIONS OF THE UPPER EXTREMITY

FRACTURE OF THE CLAVICLE

The treatment of the common *fracture of the middle of the clavicle* has given rise to so much difficulty that dozens of different methods of treatment have been described The difficulty is to control the displaced outer fragment to which the whole fore-quarter is attached and to hold it in line with the medial fragment Fortunately union occurs rapidly and satisfactorily in the vast majority of cases whatever the treatment employed and the young surgeon will be well advised to stick to one simple method The figure-of-eight bandage method is the one recommended for general use

The surgeon stands behind the patient who is *seated on a stool*, and arranges large thick pads of wool in front of each shoulder and passing back into each axilla. A 4 to 6 in domette bandage is then









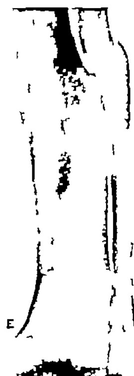
FIG 83

Ununited fracture of tibia, treated by sliding inlay graft, fixed with autogenous bone pegs, after removal of sclerosed bone

(a), (b) Non union Note dense sclerosis of bone ends.

(c) After grafting

(d), (e) Soundly healed



applied as a figure-of-eight round both shoulders the injured shoulder being drawn backwards with each successive turn of the bandage Great care must be taken to see that the axillary folds and the axillary vessels are protected by the wool pads from friction and pressure Several bandages are applied in this way and are securely fixed in position The forearm is supported firmly in a triangular sling over the sound shoulder Active exercises of finger wrist and elbow joints are carried out regularly from the first, and in older patients gentle shoulder movements should be begun after a few days to prevent shoulder stiffness The bandage should be reapplied every four or five days and may be discarded in three weeks when as a rule, there is clinical evidence of union

The less common *fracture of the outer third of the clavicle* seldom presents much displacement It can be treated either by supporting the arm in a sling for a few weeks or by the strapping method employed for dislocation of the acromio-clavicular joint

Dislocations of the Clavicle

In Dislocation of the Sterno-clavicular Joint the medial end of the clavicle is usually displaced forwards and downwards Reduction is easily accomplished by pulling the shoulder on the affected side backwards and pressing the bone into place but the position is not easily maintained Methods of fixation similar to those used for fracture of the clavicle may be tried Operative treatment is rarely called for as incomplete reduction seldom causes trouble

In Dislocation of the Acromio-clavicular Joint the acromion is depressed below the level of the clavicle by the weight of the upper limb The displacement is easily corrected by pushing up the arm and pressing down the clavicle The method of fixation is as follows Protective pads preferably of adhesive felt are placed over the outer end of the clavicle and under the olecranon the elbow being flexed to a right angle and a collar and-cuff sling is applied The centre of a strip of 2 in adhesive strapping 30 in long is placed on the pad below the elbow and one end carried up in front of the shoulder and the other behind The arm is forcibly pushed upwards and the end of the clavicle downwards and the ends of the adhesive are firmly fixed to the skin over the front and back of the shoulder crossing over the end of the clavicle A second and third strip of strapping may be applied over the first each being drawn very firmly The adhesive strips should be kept in position for three or four weeks being reinforced by further strips as required and a sling worn to take the weight of the arm for a further two weeks

Fracture of the Scapula

Fracture of the Body of the Scapula is best treated by firm strapping The strips of adhesive pass from each shoulder diagonally across the injured scapula to the chest wall on the opposite side. The arm is

supported in a sling and early active movements of all joints encouraged

Fracture of the Neck of the Scapula can usually be treated satisfactorily by supporting the arm in a sling or on an abduction splint and encouraging early movement If the fracture is mobile and the glenoid fragment tends to become displaced downwards traction on an abduction frame may be necessary Disability following this injury *in common with other injuries about the shoulder joint* is usually due to stiffness of the shoulder joint especially in middle aged and old people and treatment should be as far as possible designed to allow and promote early active movement of the joint rather than to immobilise the fracture with unavoidable fixation of the joint

Dislocation of the Shoulder Joint

The common subcoracoid dislocation is reduced by Kocher's well known method while the subglenoid dislocation may be corrected by the heel in axilla method *A sling to support the arm and* a body bandage may be worn for a few days but active movements should be started early the range of abduction being gradually increased *The rate of recovery* depends largely on the age of the patient



Fig 84

Dislocation of the shoulder joint with fracture of greater tuberosity Treated by reduction of the dislocation, followed by immobilisation on an abduction splint

The common complications are paresis or paralysis of the deltoid *due to stretching of the axillary* nerve and fracture of the greater tuberosity When either of these complications is present the arm should be treated on an abduction *splint* Occasionally the dislocation of the shoulder joint becomes recurrent and operation may be required to cure the disability

Fractures of the Upper End of the Humerus

In the treatment of these common fractures it is important to stress the need for maintaining the function of the shoulder joint rather than for securing exact anatomical alignment of the fragments In middle-aged and elderly patients especially it is often wise to ignore minor degrees of displacement and to concentrate on early active movement of the joint

Fracture of the Greater Tuberosity due to direct contusion or occurring as a complication of dislocation usually shows no displace-

ment and does not require immobilisation The forearm is supported in a sling and early active movement encouraged Heat massage and assisted movements, particularly in elderly patients, will help to prevent stiffness of the shoulder joint When the fracture is due to avulsion of the insertion of the supraspinatus tendon the small bone fragment may be pulled on to the upper aspect of the joint and the displacement can be corrected only by bringing the main fragment up to *the smaller fragment* This is accomplished by putting the arm on an abduction splint or in a plaster spica in a position of 90° abduction and about 60 external rotation The splint is retained for six or eight weeks when the ability of the patient to raise and hold the arm off the splint may be tested If this is found possible the splint may be discarded and treatment by active exercises and physiotherapy instituted



Fig 85

Fracture of neck of humerus with slight displacement. No reduction required.

Fracture of the Neck of the Humerus without displacement is treated by support and early movement

Adduction Fracture of the Neck of the Humerus i.e one in which the lower fragment is adducted in relation to the upper fragment is frequently impacted on the medial side and little displacement is present Treatment varies *with the age of the patient and the degree of displacement* In the middle-aged and elderly the impaction should not be undone nor should any attempt be made to correct the deformity which is usually slight In the young where injury may take the form of a *separation of the upper humeral epiphysis* the deformity unless very slight should be corrected by strong manual traction on the limb followed by abduction. After reduction confirmed radiologically the limb should be rested on an abduction splint for four weeks

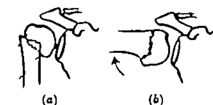


Fig 86

Fracture of the neck of humerus.—Adduction fracture

(a) Adduction fracture.
(b) Correction by abduction of shaft

Abduction Fracture of the Neck of the Humerus is one in which the shaft is abducted in relation to the head, and the upper end of the shaft may be impacted into the upper fragment on the outer side Displacement is usually slight Impaction should not be undone and the fracture should be treated on active lines the arm being supported in a sling for a few weeks

Rarely gross displacement occurs in this fracture The upper

end of the shaft is displaced medially by the pectoralis major until it lies directly under the shoulder joint while the upper fragment is abducted and rotated externally by the muscles inserted into it Reduction is obtained by placing the closed fist in the axilla while the other hand grasps the elbow and strongly adducts the arm carrying it across the body and so levering out the upper end of the shaft The limb is then supported in a sling with an axillary pad and body bandage active movements of the elbow wrist and fingers are begun at once and shoulder movements in three weeks

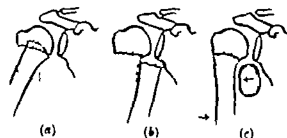


FIG 87

Fracture of neck of humerus.—Abduction fracture

(a) Abduction fracture
(b) Abduction fracture with gross displacement.
(c) Correction of abduction fracture by adduction of shaft.

Fracture Dislocation of the Shoulder is a rare injury in which the dislocation occurs first and the dislocated bone is then fractured through the neck The dislocated and separated head usually lies upside down in the subcoracoid position while the arm hangs by the side The method of reduction is to bring the shaft of the bone into alignment with the displaced head by applying traction on the arm and gradually bringing it into a hyperabducted position When this has been achieved the head is pushed upwards by a hand in the axilla and the dislocation so reduced The arm is then brought to the side an axillary pad and body bandage applied and the forearm supported in a sling The after treatment is on the usual lines for shoulder injuries

FRACTURES OF THE SHAFT OF THE HUMERUS

Fracture of the shaft of the humerus may occur at any level Displacement is frequently slight and is often dependent on the action of muscles attached to the fragments As a rule it is not difficult to bring the fragments into alignment by traction and manipulation, if necessary under anæsthesia

Simple fractures with little or no displacement are treated by local splints of wood or plaster the forearm being supported in a sling The U-shaped plaster slab is convenient and efficient Made of 3 or 4 in plaster bandages it extends from the axilla down the inner side of the arm under the flexed elbow and up the outer side to the shoulder It is applied without padding and bandaged on in the usual way Active movements of the wrist and fingers are carried out from the beginning and shoulder movements encouraged after a few weeks. The plaster may require renewal and may be discarded when there is clinical evidence of union usually in about five weeks

In some fractures of the shaft simple fixation as described above is not sufficient to maintain reduction Continuous traction may be necessary and this may be applied by the use of skin traction and

a Thomas arm splint a Jones humerus traction splint, or an abduction splint

Attention must be drawn to two possible complications of fracture of the shaft of the humerus The first is injury to the radial nerve shown by the presence of paralytic drop-wrist (p 161) The second complication is slow union As a rule oblique fractures of the shaft heal very satisfactorily but in transverse fractures occasionally slow healing is encountered As soon as this is recognised steps must be taken to immobilise the fracture completely This involves fixation of the shoulder and elbow joints to accomplish which a shoulder spica is necessary The shoulder joint should be in about 60° to 70° abduction with 30° forward flexion and the elbow joint approximately at 90° The hand should be supported but the fingers and wrist should not be immobilised and full movements of the fingers should be encouraged It may be necessary to continue immobilisation for some months

Fractures of the Lower End of the Humerus

These fractures may be grouped as follows

1 Supracondylar fracture (Extension injury)
2 Flexion injuries
3 Fracture of the lateral condyle
4 Separation of the medial epicondyle epiphysis
5 Rarer injuries *e.g* partial fractures of the articular surfaces

Supracondylar Fracture —This injury occurs typically in children The fracture line passes more or less transversely across the bone a short distance above the condyles and from below upwards and backwards The lower fragment is displaced upwards and backwards and may be tilted to the lateral or medial side The injury is a serious one and should be treated carefully and without delay Except in very young children in whom deformity may be corrected during the process of bone growth the surgeon must make every endeavour to obtain accurate reduction

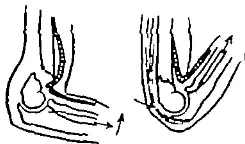


Fig 88

Supracondylar fracture—illustrating common displacement, method of reduction and danger of injury to brachial artery (and median nerve).

The child having been anaesthetised the surgeon grasps the wrist with his right hand (for fracture of the right arm) and exerts steady traction on the forearm to overcome the upward displacement of the lower fragment His left thumb is placed over the front of the arm just above the elbow *i e* over the lower end of the upper fragment while the fingers of the left hand pass behind the elbow Maintaining traction he presses backward with the left thumb and lifts the elbow forward with the fingers gradually bringing the forearm up into flexion The degree of flexion varies with the amount of swelling present.

If the latter is severe it may not be possible or safe to flex the elbow beyond a right angle If swelling is slight an angle of 45 may be reached The arm must never be forced into flexion as severe injury may thereby be done to the brachial artery When the main displacement has been corrected attention is directed to correcting

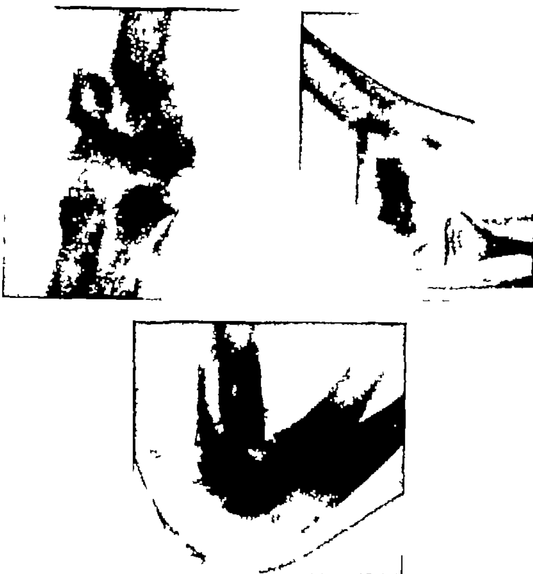


FIG 80

Supracondylar fracture: showing backward and lateral displacement. Lateral view of same after reduction.

lateral displacement Without altering the position a posterior plaster splint is applied from the axilla to the hand and bandaged lightly to the limb with a cotton bandage and finally a collar-and-cuff sling is applied to support the arm The plaster splint may be omitted The reduction may be carried out under the fluoroscopic screen and in any case should be checked by radiography on completing the manipulation and fixation If reduction is unsatisfactory a further attempt may be made immediately or in a few days time when swelling will have subsided to some extent

After reduction of a supracondylar fracture the circulation to the hand and forearm must be watched carefully. Absence of the radial pulse, pallor or cyanosis of the fingers, inability to move the fingers, pain and sometimes anaesthesia strongly suggest the onset of Volkmann's ischaemic paralysis. If such signs are present the splint and sling must be removed at once, the arm elevated and carefully watched hour by hour. If the signs persist operation should be undertaken without delay on the lines indicated on p. 200.

The splint is removed in three or four weeks and the degree of flexion of the elbow gradually lessened. The collar-and-cuff is replaced by a triangular sling and active movements encouraged. All passive flexing and extending of the joint must be expressly forbidden and the child encouraged to increase the range of movement by active use. Gradual improvement occurs over a period of many months and the temptation to hasten matters by passive movements must be resisted.

Flexion Injuries.—In these fractures the joint is in flexion at the time of injury and the small distal fragment is displaced forwards instead of backwards. The fracture may be transversely above the condyles or there may be a separation of the epiphysis. The displacement is most readily corrected by applying traction to the arm and extending the elbow joint. In some cases after reduction the joint may be flexed, but if this tends to reproduce the displacement it is better to immobilise the arm in extension. The disadvantage is that flexion is more slowly regained than extension, but as these injuries usually occur in children and young people whose joints recover well after immobilisation the disadvantage is not so serious as it might appear.

The *T or Y shaped fracture* results from a fall on the bent elbow, the wedge-shaped articular surface of the olecranon being driven against the lower end of the humerus, splitting it in a vertical direction and bursting apart the two halves of the lower end of the bone. The displacement may be gross, but every effort should be made to reduce the fracture by closed methods and operation should seldom be undertaken. Reduction is effected by strong traction applied to the upper part of the flexed forearm followed by lateral compression of the lower end of the humerus. The arm is immobilised with the elbow at a right angle in a plaster case extending from the upper arm to the lower forearm.

Fracture of the Lateral Condyle.—In this injury, which usually occurs in children, the line of fracture passes obliquely from just above the lateral epicondyle downwards and medially through the epiphyseal cartilage to enter the elbow joint through the trochlea. The smaller fragment therefore consists of the capitellum, part of the trochlea and a small part of the metaphysis on the lateral side. Attached to this fragment is the common extensor origin. If there is no displacement the fracture is treated with the elbow flexed as for a supracondylar fracture. Frequently, however, the small fragment is grossly displaced by the pull of the extensor muscles, being displaced laterally and rotated on a horizontal and sometimes also on a vertical axis. The

lesser degrees of displacement may be corrected by manipulation the joint being opened up on the lateral side by adducting the forearm and the fragment pushed and rotated back into position by thumb pressure If this manoeuvre fails as it probably will when the displacement is gross operative reduction must be undertaken The fracture is exposed and the fragment accurately replaced without interfering with its muscular and ligamentous attachments No internal fixation is necessary other than one or two catgut sutures After treatment is on the usual lines

Separation of the Medial Epicondyle Epiphysis—This is an avulsion injury the small bony fragment being torn off by the common flexor origin which is attached to it Commonly the small epiphysis is pulled distally Such displacement can be ignored the arm being treated with the elbow flexed in a collar-and-cuff sling Union is by fibrous tissue but no disability results Occasionally the abduction of the forearm which causes this injury is carried to such a degree that the medial collateral ligament is torn the joint is opened on the inner side and the epiphysis still attached to the muscle origin passes into the joint and is trapped there when the forearm bones snap back into place The fragment must be removed from the joint, and this may be accomplished by manipulation in recent cases The forearm is gently abducted to open the inner side of the joint and traction is made on the fragment by stretching the pronator and flexors attached to it i e by supinating the fore arm and extending the wrist and fingers If this fails the inner side of the joint is exposed by a short incision a hook is passed round the flexor origin which is plainly seen passing into the joint and the forearm being slightly abducted the bony nodule is extracted by giving the hook a sharp pull The epiphysis is stitched back to its position with catgut and the operation may be completed by performing an anterior transposition of the ulnar nerve neuritis of which may result from the injury or may develop later as a result of irregularity of its bony groove



FIG 00

Displacement of epiphysis of medial epicondyle into elbow joint—lateral view

FRACTURE OF THE OLECRANON

(a) *With Slight Separation of the Fragments*—Treatment should be on conservative lines The arm is rested on a pillow in bed or in a sling and gentle active movements encouraged from the outset Massage heat etc are helpful Progress is usually steady and the result satisfactory even if union is by fibrous tissue only which is not necessarily the case

Fracture of the Shaft of One or Both Bones is treated as described on p 230 The position of the fragments must be controlled by repeated radiography for as the swelling subsides the displacement is apt to recur, and it may be necessary to renew the plaster During the period of fixation full shoulder and finger movements are carried out



Fig 95
Fracture of both bones of the forearm In plaster after reduction by method shown in Fig 3.

Fracture of the Upper Third of the Ulna with Dislocation of the Upper End of the Radius is a classical injury The common displacement is forward angulation at the site of fracture and forward dislocation of the head of the radius but exactly the opposite displacements may occur The displacement may be corrected in the recent case by applying manual traction as for fracture of the forearm bones and then by pressing the upper ends of the forearm bones firmly backwards This reduces the dislocation and corrects the forward angulation of the ulna The limb is immobilised as for fracture of both bones and immobilisation should be prolonged as healing is slow In many cases however the orbicular ligament is disrupted and operation is necessary to secure accurate reposition and retention of the head of the radius If the displacement and angulation are backwards traction is applied with the elbow extended displacement corrected by forward pressure and the limb immobilised in the extended position



Fig 96
Fracture of both bones of the forearm. Six weeks later showing maintenance of position and callus formation.

Fracture of the Shaft of the Radius with Dislocation of the Inferior Radio-ulnar Joint—The fracture occurs in the lower third of the radius and is of importance because (1) the fracture is very unstable and difficult to immobilise (2) the lower fragment is usually tilted forward, pushed upwards and its upper end pulled towards the ulna This means that the inferior radio-ulnar joint is subluxated and its movement will be permanently

impaired if the displacement is not corrected Reduction is obtain by manual traction the operator pulling chiefly on the patient thumb with the limb held in the mid pronation position A plaster splint is then applied If it is found that displacement recurs, continuous traction on the thumb should be maintained by extension tapes attached to a metal hook incorporated in and projecting beyond the plaster Regular X ray examination and renewal of the plaster when necessary are essential if a perfect reduction is to be maintained and again immobilisation should be prolonged Operative fixation of this fracture may be necessary

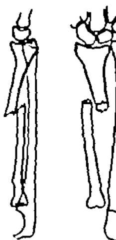


Fig 9
Fracture of shaft radius and ulnar s loid process with c location of infer radio-ulnar joint

Fractures of the Lower End of the Radius

The treatment of fractures in this situation of which Colles fracture is the commonest is usually straightforward The method of reduction is by traction and manipulation The Jones manipulation for Colles' fracture is well known Before beginning to treat the fracture it is important to have a clear and accura idea of the displacement present and to base the manipulation f reduction on this knowledge The usual displacements of the low fragment are (1) backward displacement and rotation (2) outwa displacement (3) upward displacement

After steady traction on the hand for a minute or two to un impaction the backward displacements are corrected by forcing t small fragment forward and rotating it forward and fully pronati the hand Firm pressure is then exerted on the radial side of t wrist to correct the outward and upward displacement Immobilisati is by a dorsal plaster slab or plaster case extending from the knuck to below the bend of the elbow the wrist being straight If a sl is used it should be 6 in wide and should be applied well round t radial side where it is carefully moulded so as to grip the lower e of the radius A strip of bandage must cross the palm of the har but the greatest care must be taken to ensure that this strip does n extend further distally than the distal flexion crease and so does n interfere with full flexion movements at the metacarpo phalange joints

The importance of early active movement of all free joints and early functional use of the limb is nowhere greater than after Coll fracture If the plaster is properly applied shoulder elbow and fing movements can be carried out through their full range from the outs and the limb can be used in a normal manner for a great ma purposes The plaster should be retained for five weeks, not le and sometimes more No harm results from the retention of the plast for a week or two longer provided that the limb is being freely exercis and used

fracture, the anterior and posterior marginal fractures of t
fracture of the radial styloid separation of the lower radial



Fig 98
Colles fracture; showing a slight but common degree of displacement. The in plaster showing accurate reduction.

etc The principles of treatment are the same for all. The of reduction varies with the displacement but the method of is as described above

Injuries of the Carpal Bones

The only two common injuries are fracture of the n (scaphoid) and dislocation of the semilunar (lunate) bone

Fracture of the Navicular is treated by prolonged complete im sation in plaster The plaster extends from the upper forearm knuckles as for a Colles fracture but differs from the latter in that the wrist is dorsiflexed the whole of the first metacarp and the proximal phalanx are included in the plaster and the l so firmly gripped that no carpal movement is possible Full

movements should, however, be possible especially full flexion at the metacarpo phalangeal joints

Fixation should be maintained until there is indisputable radiographic evidence of bone union in all views anteroposterior lateral, and oblique In a recent fracture well immobilised union may be present in six weeks but in old fractures immobilisation for three six or even twelve months may be necessary As long as there is no evidence of sclerosis at the site of fracture rigid immobilisation may lead to healing even though the fracture be many months old If sclerosis develops the fragments should be drilled to establish new tracks for osteogenesis and immobilised by a small bone graft from the tibia or ulna If this fails and a painful arthritis develops arthrodesis of the wrist may be performed (p 311)

Dislocation of the Semilunar Bone is almost invariably forward Reduction may be accomplished by either of the following methods



Fig 99

Fracture of navicular treated by immobilisation in plaster showing healing

(1) The arm is arranged as for reduction of a fracture of the forearm bones (p 230) Very steady and very prolonged traction is then made on the fully extended fingers the latter being wrapped in bandages fixed on with mastisol so as to give the surgeon a better grip The space for the dislocated bone is thus opened up and the bone pressed back into position by the pressure exerted on it by the taut flexor tendons. (2) With the arm arranged as above traction is exerted on the fingers by an assistant and the wrist fully dorsiflexed The surgeon then exerts strong pressure on the volar aspect of the *wrist* directly over the dislocated bone with his thumbs and the assistant still exerting traction carries the wrist into full flexion Reduction must be confirmed by X ray As the reduction is stable *immobilisation* for a week or two suffices

If closed reduction fails the dislocated bone should be *removed* A volar incision is made through the transverse carpal ligament between the flexor carpi radialis and palmaris longus the median nerve is drawn laterally and the *flexors* of the fingers medially The functional result is surprisingly good.

fracture the anterior and posterior marginal fractures of the radius, fracture of the radial styloid separation of the lower radial epiphysis,



Fig 98
Colles fracture: showing a slight but common degree of displacement The same in plaster showing accurate reduction.

etc The principles of treatment are the same for all The method of reduction varies with the displacement but the method of fixation is as described above

Injuries of the Carpal Bones

The only two common injuries are fracture of the navicular (scaphoid) and dislocation of the semilunar (lunate) bone

Fracture of the Navicular is treated by prolonged complete immobilisation in plaster The plaster extends from the upper forearm to the knuckles as for a Colles fracture but differs from the latter plaster in that the wrist is dorsiflexed the whole of the first metacarpal bone and the proximal phalanx are included in the plaster and the hand is so firmly gripped that no carpal movement is possible Full finger

movements should however, be possible, especially full flexion at the metacarpo-phalangeal joints

Fixation should be maintained until there is indisputable radio graphic evidence of bone union in all views anteroposterior lateral and oblique In a recent fracture well immobilised union may be present in six weeks but in old fractures immobilisation for three, six or even twelve months may be necessary As long as there is no evidence of sclerosis at the site of fracture rigid immobilisation may lead to healing even though the fracture be many months old If sclerosis develops the fragments should be drilled to establish new tracks for osteogenesis and immobilised by a small bone graft from the tibia or ulna If this fails and a painful arthritis develops arthrodesis of the wrist may be performed (p 311)

Dislocation of the Semilunar Bone is almost invariably forward Reduction may be accomplished by either of the following methods



Fig 99

Fracture of navicular treated by immobilisation in plaster showing healing.

(1) The arm is arranged as for reduction of a fracture of the forearm bones (p 230) Very steady and very prolonged traction is then made on the fully extended fingers the latter being wrapped in bandages fixed on with mastisol so as to give the surgeon a better grip The space for the dislocated bone is thus opened up and the bone pressed back into position by the pressure exerted on it by the taut flexor tendons (2) With the arm arranged as above traction is exerted on the fingers by an assistant and the wrist fully dorsiflexed The surgeon then exerts strong pressure on the volar aspect of the wrist directly over the dislocated bone with his thumbs and the assistant still exerting traction carries the wrist into full flexion Reduction must be confirmed by X ray As the reduction is stable immobilisation for a week or two suffices

If closed reduction fails the dislocated bone should be removed A volar incision is made through the transverse carpal ligament between the flexor carpi radialis and palmaris longus the median nerve is drawn laterally and the flexors of the fingers medially The functional result is surprisingly good.

Fracture of the First Metacarpal

Bennett's Fracture or fracture dislocation is highly unstable and frequently reduction can only be maintained by continued traction. The displacement is easily reduced by traction on the thumb in a slightly abducted position *followed by firm pressure applied over the* base of the metacarpal While an assistant maintains a steady pull on the thumb an unpadded plaster case is applied from the lower forearm to the knuckles dorsally and to the transverse flexion crease *on the palmar surface* The *plaster on the thumb* reaches the base of the proximal phalanx While the plaster is setting thumb pressure is applied to the plaster overlying the base of the metacarpal and when it has set a strong wire is incorporated in it This wire lies in the axis *of the thumb and extends* an *inch or two beyond it It is notched* or hooked at its distal end and extension tapes attached to the thumb are tied to the hook or notch Traction should be maintained for six weeks and plaster fixation continued for a further two weeks

Fractures of the Shafts of the Metacarpals

Oblique Fractures are due to indirect violence and usually show slight overriding but no other deformity It is not necessary to maintain correction of the slight shortening which results as it causes no disability A dorsal plaster slab to which the hand is bandaged gives adequate rest and protection and is worn for a few weeks

Transverse Fractures may show dorsal angulation a disabling deformity which must be corrected This is accomplished by traction on the flexed finger plus correction of the deformity by local dorsal pressure at the site of fracture Immobilisation is secured by applying a dorsal plaster splint which extends from the lower forearm to the knuckles with an extension along the dorsum of the affected finger which is flexed at all its joints Immobilisation is maintained for four or five weeks

Fracture of the Neck of a Metacarpal Bone with forward tilting of the head is an injury which causes disability if the deformity is not corrected Reduction is effected by flexing the metacarpo phalangeal joint to a right angle and pushing the head of the bone backwards by means of the first phalanx When corrected immobilisation is maintained as for transverse fractures with displacement

Fractures and Dislocations of the Phalanges

Fracture of the Proximal Phalanx is the most frequent injury The fracture is usually near the base of the bone and the fragments are angulated forwards *the deformity being due to the pull of the* lumbrical and interosseous muscles If uncorrected the deformity leaves a seriously disabled finger Reduction is by traction and flexion and immobilisation by use of a plaster case extending from the forearm to the knuckles *in which is incorporated* a palmar finger splint The

finger is bent as shown in Fig 100 and strapped to the finger splint or attached to its end by a stainless-steel wire transfixing the pulp

Fractures of the Other Phalanges with displacement may be treated on similar lines but simple fractures without displacement are sufficiently immobilised by a few turns of plaster bandage

Dislocation of the Metacarpo-phalangeal Joint of the Thumb often presents difficulty owing to the tendons of the short flexor with their sesamoid bones or the joint capsule interfering with reduction. Closed reduction may be accomplished by grasping the dorsally displaced proximal phalanx and carrying it forcibly distally before attempting to bring it into flexion If this fails a short incision is made anteriorly over the metacarpal head the latter freed from entanglement and the dislocation reduced

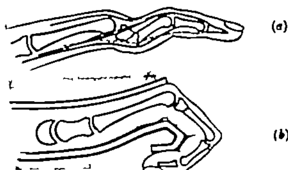


Fig 100
Fracture of proximal phalanx with backward angulation.
(a) Common deformity
(b) Position for maintaining reduction and method of splinting

Dislocation of the Finger Joints is usually easily reduced by simple traction Several turns of adhesive strapping round the joint give sufficient fixation after reduction.

FRACTURES AND DISLOCATIONS OF THE LOWER EXTREMITY

Dislocation of the Hip Joint

The common dislocation is a posterior one the typical deformity being one of adduction and internal rotation of the thigh and shortening of the limb In anterior dislocation the thigh is abducted and externally rotated and there is no shortening The posterior variety may be complicated by marginal fracture of the acetabulum Both types of dislocation are reduced in a similar manner The patient is anaesthetised on a mattress on the floor and the knee and hip joints are each flexed to a right angle An assistant steadies the pelvis The internal or external rotation and adduction or abduction are gently corrected and the thigh is lifted vertically upwards by steady traction exerted by one arm placed behind the upper end of the tibia while the other hand controls the foot This manœuvre lifts the head forward till it lies opposite the acetabulum and with a little manipulation the head slips into place

If there is no fracture of the acetabulum reduction is stable and in the absence of severe muscle and ligamentous injury immobilisation is unnecessary Gentle active movements may be begun soon and weight bearing allowed in a few weeks If a portion of the rim of the acetabulum has been detached if there has been much tissue damage,

or if the dislocation is not very recent immobilisation in a plaster spica is advisable

Complications after dislocation of the hip joint are avascular necrosis of the head of the femur ossification in the surrounding muscles and injury to the sciatic nerve

Fracture of the Neck of the Femur

The *Abduction Fracture* is an uncommon one in which the neck and shaft are abducted in relation to the head The fracture is often incomplete on the under surface while it is impacted on the upper surface As there is no tendency to displacement no reduction or retentive apparatus is required The patient should remain in bed for a few weeks during which time active exercises for the knee and hip are carried out. Thereafter weight bearing may be allowed



Fig 101
Impacted abduction fracture of neck of femur

Adduction Sub-capital and Transverse Fractures are the common fractures of the neck of the femur which in the past have given rise to great difficulty in treatment because of their liability to non union The problems of treatment have been largely solved by the use of the Smith Petersen three flanged stainless steel nail fixation of the fracture by this means being the accepted method of treatment to-day

In very feeble patients in whom the risk of operative treatment small though it be is considered unjustifiable treatment consists in applying traction to the limb by means of extension tapes and a weight over the end of the bed and careful nursing The greatest danger to life apart from initial shock is hypostatic pneumonia The weight extension diminishes the pain and makes nursing easier but has little effect in controlling the fracture which will not unite

When there is any doubt as to the advisability of operating the following points should be borne in mind (1) The fracture will almost certainly not unite without operation (2) There is approximately a 60 per cent chance of union if operation is successfully performed (3) Nailing the fracture will at once abolish the pain will allow the patient to move in bed and sit up and will facilitate nursing Indeed, operation is often the best means of preventing such serious

complications as hypostatic pneumonia pulmonary embolism and bed sores (4) The operation though lengthy produces little shock as it requires a very limited exposure and can be done under local or light general anæsthesia

Operation for Fracture of the Neck of the Femur—The operation should be performed within a few days of the injury since delay increases the risk of pulmonary embolism

The fracture must first be reduced on an orthopædic or fracture table by traction strong internal rotation and abduction Both feet are bandaged to the foot pieces of the table and both legs fixed in an equal degree of abduction about 30° to 40° the injured leg being fully rotated internally Anteroposterior and lateral X rays are taken to confirm reduction

The lateral aspect of the base of the great trochanter and of the

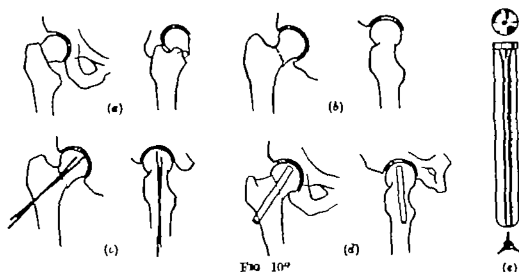


Fig 109

Fracture of neck of femur Drawings made from X rays of a case

(a) A.P and lateral views before reduction.
(b) Same after reduction—patient on orthopædic table.
(c) Guide wires inserted, one in perfect position (the other is withdrawn)
(d) Smith Petersen nail in position and guide wire withdrawn—fracture impacted.
(e) Cannulated Smith Petersen nail, showing also end view of head and point. (*Watson-Jones.*)

upper part of the shaft is then exposed by a straight incision The lower margin of the trochanter is identified and a small opening made in the cortical bone ½ in below this point and exactly midway between the anterior and posterior aspects of the bone With or without the aid of one of the many devices that have been described a guide wire is passed through the cortical opening up through the neck of the femur into the head and its position checked by radiography and if necessary adjusted. A cannulated Smith Petersen nail of suitable length is threaded over the guide wire and tapped into the bone right up to its head by the use of a cannulated punch and a mallet The guide wire is withdrawn and the fragments impacted with an impactor punch A cross pin passed through a special drill hole in the head of the nail may be used to prevent the nail slipping out of the bone

The after treatment is simple Gentle active movements of the limb are encouraged after a few days and fuller movements are begun

as soon as the stitches are removed The patient may be allowed up to sit in a chair after a week or two but weight bearing should



Fig 103
Basal fracture of neck of femur unsuitable for fixation with the Smith Petersen pin. Treated by multiple wire nail fixation (Austin Moore).

not be allowed until there is evidence of union at least in the more serious vertical and subcapital fractures

In about 40 per cent of cases for various reasons the operation fails and non union results In these and in untreated cases an oblique osteotomy just above the lesser trochanter is the treatment of choice (p 331)

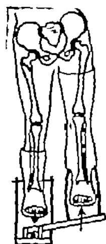


Fig 104
Roger Anderson splint applied.

Basal Fractures of the Neck of the Femur usually heal satisfactorily They are not suitable for internal fixation by nailing unless the trochanteric part of the bone is thick and unsplintered (intertrochanteric fractures) The choice of treatment lies between fixation in a plaster spica with the limb in abduction continuous traction with the limb in abduction or fixed traction in the Roger Anderson well leg traction splint

Subtrochanteric Fractures of the Femur

The line of fracture is through the upper shaft just below the lesser trochanter Attached to the upper fragment are the abductors and a strong flexor and external rotator the iliopsoas The proximal fragment is therefore flexed abducted and externally rotated and the distal fragment must be brought into alignment with it This may be accomplished by continuous traction in abduction the limb being slung in a Hodgen splint with the patient sitting up or by the use of the Roger Anderson splint In some cases especially where the fracture is transverse the short proximal fragment is acutely flexed and cannot be controlled by traction Operative fixation by plating is then indicated.

Fractures of the Shaft of the Femur

Practically all fractures of the shaft of the femur should be treated by traction The factors which produce displacement are the initial injury the weight of the distal limb and the retraction of the powerful thigh muscles Reduction is effected by traction on the limb under local or general anaesthesia combined if necessary with manipulation Angular deformity is usually overcome by traction but lateral pressure by special pads may be necessary in addition If very heavy traction has to be employed to effect reduction it should not be continued for more than two or three weeks The essentials of a satisfactory reduction of a fracture of the shaft of a femur are (1) restoration to normal length (2) correction of angular deformity (3) preservation of the normal anterior bowing of the shaft Exact apposition of the ends of the fragments is not essential apposition of one-third of the diameter of the bone being sufficient to give sound healing and a good functional result

In children up to the age of seven or eight the most convenient method of treatment is the gallows method in which both lower limbs are slung vertically by weights and pulleys The weight applied to the limbs should be sufficient to keep the sacrum just clear of the bed. The method is efficient and comfortable and greatly facilitates nursing

In adults skin traction or skeletal traction may be used The limb may be immobilised with fixed traction by tapes to the end of the splint or by weight traction.

For *skin traction* extension strapping of brown holland or adhesive strapping is applied from the upper thigh to just above the ankle the outer strip being placed rather behind the inner rather in front of the midline of the limb so as to counteract the tendency to external rotation The strips are bandaged firmly and evenly to the limb with a soft bandage which stops a short distance above the ankle

For *skeletal traction* the transfixing wire or pin may be passed through the lower end of the femur above the condyles or through the upper end of the tibia The latter is the better and safer site and a pin is preferable to a Kirschner wire It should be tapped into the bone with a mallet not screwed in It should pass through the tibia about ¾ in. deep to the tuberosity The knee must be flexed and a Thomas splint with a flexion piece or a Böhler Braun splint is used to support the limb Heavy traction can be exerted by this method and care must be taken not to overdo it and produce lengthening of the limb It is strongly recommended that skeletal traction should be replaced by skin traction after about four weeks

Fixed traction is especially useful in cases which may have to be transported A well fitting Thomas splint is necessary The ring should measure 1½ in more than the horizontal circumference of the thigh at its highest point and the inner bar of the splint should be 7 to 8 in longer than the medial side of the limb

The ring of the splint should be adjusted to bear against the ischial tuberosity The slings are adjusted so that two thirds of the

limb lie in front of the bars of the splint Firm pads are placed behind the limb at the level of the fracture to maintain the normal anterior bowing and behind the knee joint to keep it slightly flexed The tape attached to the outer extension strapping is carried over and that on the inner side under the corresponding side stem of the splint and the two tapes are tied tightly together in the notch at the end of the splint The foot-piece is adjusted so as to maintain the foot at right angles to the leg The lower end of the splint is elevated about 6 in from the bed It may be tied to the foot of the bed and the latter raised on blocks so as to ease the pressure of the ring on the ischial tuberosity and the groin

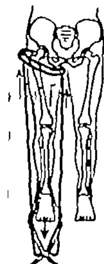


Fig 105
Thomas splint applied

The above arrangement may be supplemented by the use of splints the purpose of which is to give greater local fixation A gutter splint extending from the upper thigh to the calf may be laid on the slings passing between the side stems and short gutter or Gooch splints may be applied to the anterolateral aspects of the thigh and bandaged in position

Weight traction is more generally useful A Thomas splint with knee flexion piece may be used or Hodgen's splint or the Böhler Braun splint if preferred An initial weight of 25 lb or over may be required When the position of the limb has been corrected it may be reduced to 15 lb If a Thomas or Hodgen's splint is used the splint itself may be slung by weight and pulley to an overhead beam to facilitate moving the patient for the use of the bedpan

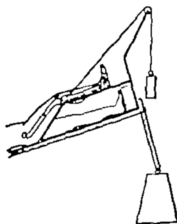


Fig 106
Böhler-Braun splint applied.

The *after-care* of the fracture is all important In fixed traction the extension tapes must be adjusted two or three times a day and constant attention must be given to the skin subjected to pressure by the ring The position of the fragments is controlled by repeated X ray examination and the slings supporting the limb adjusted as required The patient is encouraged from an early stage to carry out frequent contractions of the quadriceps muscle and to exercise the ankle and toes Immobilisation must be maintained until there is evidence of union, usually eight to ten weeks The patient should then be fitted with a Thomas walking caliper splint and encouraged to get about The splint is removed frequently for knee exercises and eventually discarded when consolidation of the fracture is complete

The commonest complication following treatment of a fractured femur is stiffness of the knee joint a complication that is more trouble-

some as age advances It is due to shortening of the quadriceps muscle and to adhesions which are particularly troublesome if skeletal traction through the lower end of the femur has been used The treatment is by active movements and by heat and massage When improvement has ceased manipulation may be advised It must be done with care owing to the risk of fracturing the patella

Supracondylar Fracture of the Femur

In this fracture the lower fragment is usually tilted backwards by the gastrocnemius The displacement is a troublesome one It is overcome by the use of tibial skeletal traction with the knee flexed about 45° the limb being placed with the angle of the splint opposite the fracture instead of opposite the knee joint The sequence of treatment is on the same lines as for fracture of the shaft

Displacement of the Lower Femoral Epiphysis

In this injury which occurs in children the lower fragment the epiphysis is generally displaced forwards The upper fragment the shaft of the femur is drawn back by the pull of the gastrocnemius and hamstring muscles The injury may be compared with supracondylar fracture of the humerus in the child and there is a similar danger of injury to the main artery the popliteal, and of ischæmic contracture and even gangrene Reduction is accomplished by flexing the knee to relax the gastrocnemius lifting the head of the tibia forwards and applying traction on the leg Direct pressure on the displaced epiphysis may also be necessary The joint is immobilised in 90 flexion in an anterior plaster shell, and if reduction is sufficiently stable the degree of flexion may be lessened after three or four weeks and a fresh plaster applied Healing should be sufficiently advanced to allow of active movements in two months

Fracture of the Patella

Stellate Fracture —If there is no gross displacement of the fragments the injury should be treated on conservative lines by a posterior splint early weight-bearing quadriceps drill and active movements after a few weeks If the bone is comminuted and the fragments displaced to such an extent as to cause gross irregularity of the articular surface early total excision of the patella is the best treatment (see p 268)

Transverse Fracture.—Here the fracture is usually accompanied by rupture of the quadriceps expansion If the displacement of the fragments is minimal the treatment is to fix the limb in extension with a firm bandage round the knee joint Flexion may be begun in about six weeks If however the fragments are widely separated, indicating that the quadriceps expansion and the joint capsule on each side have been torn and if as so often happens the lower fragment is tilted or comminuted operative treatment is necessary The

operation may consist of suturing the fragments with catgut or wire or fascia and suturing the torn quadriceps, or of excising the fragments of the patella *in toto* and suturing the quadriceps tendon Excision of the patella an operation suggested only a few years ago and therefore to some extent on trial has much to commend it especially in elderly people The bone is exposed by a U-shaped flap turned upwards Blood clot is cleared out of the joint the fragments are carefully dissected out of their tendinous coverings and the tear is sutured by catgut mattress sutures followed by a continuous suture The power of the quadriceps does not appear to be materially affected by removal of the patella nor does the function of the knee joint Removal of the fractured bone means the removal of the weakest part of the tendon and suture of the latter is facilitated Fixation of the joint is unnecessary after this operation an important point in elderly patients The joint is firmly bandaged over a copious dressing and contraction of the quadriceps encouraged after a few days The patient may be allowed out of bed soon after the removal of stitches, and active flexion movements and walking may be begun Recovery should be fairly complete in two months

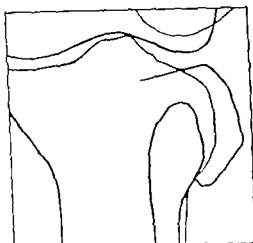
Dislocation of the Knee Joint

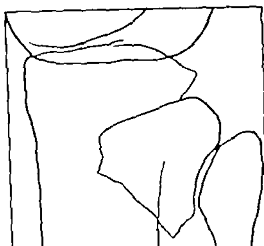
Complete dislocation of the knee joint is rare The tibia may be displaced in any direction but backward dislocation is the commonest variety Both lateral ligaments and both cruciate ligaments are necessarily completely ruptured and one or both semilunar cartilages may be injured The dislocation can usually be reduced by traction and manipulation and the joint is immobilised in plaster for ten to twelve weeks From the very beginning regular quadriceps contractions must be carried out to maintain the tone and strength of that muscle on which the stability and usefulness of the joint will later depend If forward dislocation occurs serious damage may be done to the popliteal vessels and gangrene of the foot may ensue

Fractures of the Tibia and Fibula

Fracture of the Upper End of the Tibia —The commonest fracture of the upper end of the tibia is separation or crushing of the lateral condyle The injury is due to a forcible abduction at the knee joint the whole weight of the body being concentrated through the lateral femoral condyle on the corresponding condyle of the tibia with the result that the latter is either crushed downwards or sheared off The former constitutes the more serious injury The injury is frequently accompanied by a complete rupture of the medial collateral ligament and sometimes by injury to the cruciate ligaments. The damaged condyle is depressed leading to a valgus deformity and irregularity of the articular surface If the deformity is uncorrected a serious disability of the joint results and osteoarthritis is a late sequel. Reduction is accomplished by traction and forcible adduction of the leg with the knee fully extended together with lateral compression

of the upper end of the tibia either by the surgeon's hands or by the use of a Böhler's *redresseur* After reduction the limb is enclosed in a complete plaster case split if necessary, extending to the groin, possibly combined with skeletal traction for a few weeks The case is retained for ten weeks, during the whole of which time regular active contraction of the quadriceps must be carried out The importance of restoring the quadriceps to normal after such injuries cannot be too strongly stressed Rarely operative reduction of a comminuted and grossly displaced condyle may be undertaken


(a)


(b)


(c)


(d)

FIG 107

Fracture of lateral condyle of tibia with gross downward displacement (drawn from X rays films). Operative reduction and fixation by vitallium screw

Fractures of the Shafts of the Long Bones—Isolated Fractures of the Fibula due to direct violence do not require immobilisation They are treated by a short period of rest followed by the application of a zinc gelatine bandage and active use

Isolated Fractures of the Tibia with little or no displacement require simple correction of the deformity and immobilisation in a plaster case extending from the toes to the groin for six to eight weeks

Fractures of Both Bones of the Leg whether oblique or transverse if without displacement require immobilisation as for fractures of the tibia alone though the period of immobilisation may have to be longer If with *displacement* they are more difficult to treat

Frequently they are accompanied by considerable swelling and they are difficult to reduce and slow to heal In cases without much displacement gross swelling or damage to the soft tissues an unpadded plaster case should be applied from the toes to the groin with the knee flexed after reduction of displacement by strong traction using if necessary a screw traction apparatus such as Böhler's or Watson-Jones In oblique fractures where overriding tends to recur skeletal traction should be used for three or four weeks The transfixion pin may be inserted through the tibia an inch above the ankle or through the calcaneus an inch below and behind the lateral malleolus When



(a) (b)

Fig 108

Oblique fracture of tibia and fibula with splintering of lower fragment of tibia. Owing to difficulty in controlling the fracture by conservative means, fixation by vitallium plate was carried out with success.

considerable swelling is present or expected as in crush injuries, the limb should be supported on a Braun s splint with skeletal traction for two to three weeks and plaster applied as above when the swelling has subsided

Other points in treatment which may be stressed are (1) The plaster case to immobilise fractures of both bones should always extend to the upper thigh with the knee flexed 10 to 20 (2) Complete plaster cases should be split or guttered from end to end if there is reason to expect much swelling When swelling has subsided a fresh plaster case can be applied (3) The limb enclosed in a complete plaster case should always be elevated (4) Accurate reduction of the fracture is essential, particularly restoration of length and correct alignment Minor degrees of angulation which are revealed in post

reduction X rays are readily corrected by wedging the plaster (p 231) If reduction cannot be obtained by closed methods the surgeon should not hesitate to advise open operation a simple procedure without many of the disadvantages attached to operations on more deeply placed bones After reduction if the fracture is oblique and likely to prove difficult to immobilise the fragments may be fixed by a sliding inlay graft (5) Immobilisation must be maintained till bony union is present This may mean fixation for many months as slow healing is not infrequently encountered

FRACTURES IN THE REGION OF THE ANKLE

The term *Pott s Fracture* covers a number of different injuries in the region of the ankle which may be classified as External Rotation Abduction and Adduction Fractures and Compression Fractures

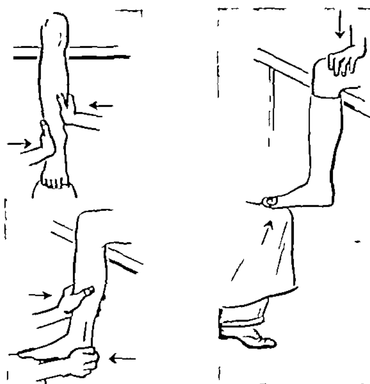


FIG 100

Method of reducing a Pott s fracture with lateral and back ward displacement. Application of plaster for Pott s fracture —maintenance of foot at right angles to leg

External Rotation Fractures of the lower end of the fibula are very common If there is no displacement and the surgeon can satisfy himself that the deltoid ligament is intact immobilisation is un necessary The injury may be treated by strapping and active use If there is displacement or evidence of rupture of the deltoid liga ment reduction and immobilisation as for other ankle fractures are necessary

Abduction and Adduction Fractures—A general anæsthetic is administered and the leg hung over the end of the table Manual

traction is applied to the foot and the heel then strongly lifted forward against counter pressure on the front of the lower leg This corrects posterior displacement of the foot and brings into position the posterior marginal fragment which is so often present The fore part of the foot is then supported on the surgeon's knee and lateral or medial displacement corrected in a similar manner There is little fear of overcorrection so that considerable force may be used so as to obtain that complete reduction of the displacement which is absolutely essential in this fracture

If the ankle is grossly swollen reduction may be delayed for a day or two and the limb temporarily immobilised and elevated or if reduced immediately and fixed in plaster the case should be split and the limb elevated Often however it is possible to reduce and immobilise the fracture at once in an unpadded plaster The case



FIG 110

Pott's fracture —Showing bi malleolar fracture with marked abduction—before and after attempted reduction. Reduction is incomplete and further manipulation must be done to obtain complete correction.

should extend from just below the knee to the web of the toes the latter being supported on a plantar extension of the plaster The case is usually built up on the basis of one or two plaster slabs one applied posteriorly from below the knee to beyond the toes and fixed on with a wet cotton bandage the other applied from the knee down the outer side of the leg below the heel and up the inner side to the same level A few circular plaster bandages then complete the case While the plaster is setting great care must be taken to prevent backward displacement to maintain full correction of the abduction or adduction deformity to maintain right-angle dorsiflexion and to mould the plaster accurately to the longitudinal arch of the foot

If post reduction X rays show that the deformities have been completely corrected a walking iron is fitted so adjusted that it lies exactly in the axis of the leg bones and projects about 2 in below the sole of the plaster Active exercises of the knee and toes are begun at once and walking encouraged Should the plaster become loose or uncomfortable owing to disappearance of swelling a fresh plaster

may have to be applied Immobilisation is maintained for six weeks in an average case and for two to four weeks longer if there has been serious displacement A zinc gelatine or elastic adhesive bandage is applied immediately after removal of the plaster and active exercises of the foot and ankle are encouraged to restore movement Heat and massage may be necessary, especially in older patients and occasionally manipulation of the foot and ankle will be required at a later stage to deal with residual adhesions

Dislocation of the Ankle Joint

While many cases of Pott s fracture are really examples of fracture dislocation of the ankle joint pure dislocation without fracture is a relatively rare injury Attention may be drawn, however to the occasional complete rupture of the anterior and middle bands of the external lateral ligament an injury which allows the talus to tilt towards the medial side in the tibiofibular mortice This injury can only be recognised by forcibly inverting the foot after the injection of a local anæsthetic into the injured ligament when the tilting of the talus may be recognised clinically or radiographically Treatment is by immobilisation in plaster for eight to ten weeks with the talus in a fully corrected position this period being necessary to allow the torn ligaments to heal Less complete or less prolonged immobilisation will result in imperfect healing and a constant tendency on the part of the ankle to give way

Fractures of the Tarsal Bones

Fracture of the Neck of the Talus occurs as a result of violent dorsiflexion of the foot There may be no displacement but sometimes the body of the bone is squeezed out of its position between the calcaneus and the tibia in a postero medial direction practically all its ligamentous attachments being ruptured and its blood supply consequently so seriously impaired that avascular necrosis results The injury then constitutes a fracture dislocation of the talus In cases of simple fracture of the neck immobilisation is all that is necessary If the body has been completely displaced removal of it or of the whole bone is the best form of treatment

Compression Fracture of the Body of the Talus occurs rarely as the result of a fall on to the feet Attempts should be made to remould the bone into shape by manipulation and if necessary by skeletal traction through the calcaneus on the screw traction apparatus Continuous traction for a few weeks may be advisable

Fracture of the Calcaneus is a disabling injury difficult to treat Isolated fractures in which a fragment is separated from the main body of the bone are treated by replacing the fragment by manipulation and immobilising the fracture in a plaster case from the knee to the toes Examples of such fractures are vertical fracture of the medial process of the tuberosity fracture of the sustentaculum tali and the so-called beak fracture of the tuberosity

The much commoner and more serious fracture is the crush fracture sustained by falling from a height on to the heel The fracture varies from a slight fissuring and compression of the bone without involvement of the talocalcanean joint to severe crushing and comminution, with upward displacement of the posterior end (the tuberosity) vertical splitting in an anteroposterior direction with widening and severe disorganisation of the talocalcanean joint This severe type of injury if untreated gives rise to prolonged disability resulting as it does in a type of flat foot in loss of the movements of inversion and eversion due to involvement of the subtaloid joint in osteoarthritis of this joint and in pain on the under surface of the heel when walking

In the absence of gross deformity of the bone and disturbance of the joint surfaces treatment consists of immobilisation in plaster for about twelve weeks In the more serious injuries an attempt may be made to correct the deformities and reform the bone It is practically impossible to restore a badly crushed calcaneus to normal form and to restore the talocalcanean joints to normal alignment Böhler has described somewhat elaborate measures to correct the deformity by screw traction applied through transfixion pins and by lateral compression by means of his redresseur It seems doubtful whether the functional results obtained justify the employment of such measures in this injury Probably equally good results are obtained by correction of broadening of the bone by lateral compression followed either by fixation in plaster without weight bearing or by simple rest in bed with active exercises Weight bearing is allowed when deep tenderness over the bone has disappeared i e usually in two to three months

Fractures of the Metatarsal Bones

Isolated fractures without displacement such as avulsion fracture of the base of the fifth metatarsal and March fracture of the second or third metatarsal require simple rest and immobilisation for a few weeks Multiple fractures with displacement are serious injuries and no effort should be spared to correct gross deformity when present Particular attention should be paid to correcting downward displacement of a metatarsal head Reduction is effected by manipulation and traction and the latter may be retained to maintain correction in conjunction with a plaster case

Fractures of the Toes

Fracture of one or other phalanx of the great toe due to direct violence is the injury most commonly encountered The fracture is usually comminuted and displacement is rare Simple fixation with turns of adhesive plaster or gauze soaked in collodion is all that is necessary Fractures of the other toes usually involve the proximal phalanges Treatment is on the same lines as for similar injuries in the fingers.

T M'W M

CHAPTER XV

AFFECTIONS OF THE SHOULDER REGION AND ARM

OPTIMUM POSITION OF SHOULDER JOINT.—In diseases likely to lead to permanent stiffness or ankylosis at the shoulder the joint should be immobilised in a position of 60° to 75° of abduction and slight external rotation at the scapulohumeral joint. The movement of the scapula on the chest wall then enables the arm both to be brought to the side and to be elevated a considerable way above the head.

The axis of the humerus should be at right angles to the glenoid surface, that is about 30° in front of the coronal plane. To secure the proper position the elbow must be brought forward until it lies in the plane of the anterior surface of the body. Abduction without this adjustment is uncomfortable after a short time, since the anterior fibres of the deltoid are stretched.

Even in injuries from which full recovery is expected, it is a good rule to rest the shoulder joint in the abducted position whenever possible. Obliteration of the inferior capsular pouch is then prevented, and when movements are begun the effect of gravity assists in the return of function.

Aspiration of the Shoulder Joint.—The shoulder joint is generally aspirated from the side. The needle is introduced immediately below the lateral margin of the acromion and pushed in through the deltoid and the subacromial bursa.

Arthrotomy for Acute Arthritis of Shoulder.—When drainage becomes necessary in acute suppurative arthritis of the shoulder, the joint may be opened either from the front or from the back.

The posterior route (Stiles) is unquestionably the better; it is simple to perform and has the great merit of allowing dependent drainage. The incision extends downwards from the angle of the acromion in the line of the posterior fibres of the deltoid, which are split and pulled apart to display the muscles covering the capsule. The joint is opened at the lower border of the infraspinatus tendon.

The anterior incision is on the lines of the usual anterior approach for major arthrotomy (see below). If this method is used, a counter incision should be made behind by cutting down on the point of an artery forceps passed through the joint.

Exposure of the Shoulder Joint.—The *anterior route* is used most generally. The incision passes downwards from the coracoid process along the anterior border of the deltoid. The cephalic vein and the pectoralis major are retracted medially and the deltoid drawn to the

lateral side if the deltoid is very fleshy however it may be wise to detach or divide the fibres which arise from the clavicle The coracoid process and its attached muscles—the pectoralis minor the coracobrachialis and the short head of biceps—are now seen in the medial part of the wound and on the lateral side the anterior aspect of the humeral head overlaid by the tendon sheath of the long head of the biceps The bicipital fascia (transverse humeral ligament) which retains this tendon in the intertubercular (bicipital) groove is now divided and the cut extended up into the capsule of the joint The bicipital tendon is retracted medially and the joint exposed

More liberal access to the joint is only possible after dislocation of the humeral head For this step the humerus is first rotated laterally and the subscapularis which is put on the stretch by this manœuvre is detached subperiosteally from the lesser tubercle along with the capsule Medial rotation of the humerus allows the muscles and capsule attached to the greater tubercle to be similarly dealt with and the head is protruded by carrying the elbow backwards and pushing upwards in the long axis of the humerus

After the intra articular stages of the operation are completed the muscular attachments are allowed to fall back into place The capsule is repaired and the biceps tendon secured by suturing the remains of the bicipital fascia

The *posterior route* (Kocher) gives an excellent view of the superior and posterior aspects of the shoulder joint The incision passes from the acromioclavicular joint backwards across the top of the shoulder to the junction of the acromion and the spine of the scapula and thence downwards in the line of the posterior fibres of deltoid

The acromioclavicular joint is opened and the fibres of trapezius detached from the medial surface of the acromion process The process is then sawn through at its root and pulled laterally along with the attached deltoid fibres The capsule is opened immediately in front of the supraspinatus tendon and the muscular attachment at the tuberosities dealt with as in the anterior approach The head of the humerus can be made to protrude by flexion and adduction of the shoulder

RECURRENT DISLOCATION OF THE SHOULDER JOINT

The treatment of recurrent dislocation of the shoulder is now on a sound basis for the pathological features of the disability are generally recognised The essential lesion is a wide detachment of the capsule of the joint from the anterior surface of the neck of the scapula accompanied usually by detachment of the glenoidal labrum In this way a pocket is created in front of the scapular neck beneath the subscapular muscle and it is into this pocket that the head dislocates

The tear is the result of an initial traumatic dislocation and in some cases there is a clear history of violence applied to the back of the joint when presumably the head is driven straight forward and shears off the labrum In other cases the history does not differ from

that forthcoming in the ordinary case of simple dislocation without recurrence and the nature of the immediate treatment does not appear to be important in preventing subsequent redisplacements

In the majority of cases there is also an indentation on the postero-lateral surface of the humeral head when this area engages the glenoid —as when the shoulder is abducted and externally rotated—the head tends to slip out of the joint

Conservative Treatment.—Recurrent dislocation can only be cured

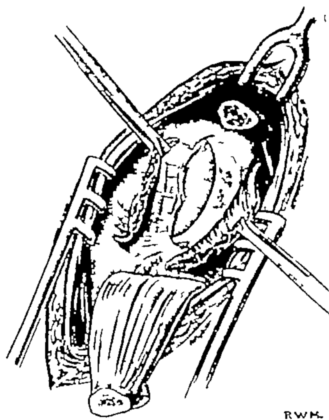


FIG 111

Bankart's operation.

The coracoid process and the attached muscles have been turned down, and the subscapular muscle incised. The anterior surface of the neck of the scapula has been "rawed" to receive the detached labrum.

by operation but it can be kept under control by conservative means if for any reason operation is contraindicated

It is necessary to check the excursion of the shoulder joint particularly into abduction and external rotation by means of an appliance This consists of a pair of leather straps one round the arm and the other round the chest with a check strap between them which limits abduction to not more than 25 In old people a simple method of controlling the dangerous movement is by pinning the sleeve of the coat (or pyjama jacket) to the side of the coat

Operative Treatment.—A formidable number of operations have

been practised , in most of them an attempt is made to fix the head of the humerus during the movements which predispose to dislocation. The more logical procedures however are those in which an attempt is made to reattach the separated capsule to the front of the neck of the scapula The two methods in common use are Bankart s in which the labrum and capsule are sutured to the anterior rim of the glenoid and the operation of Putti and Platt in which the pocket in front of the neck of the scapula is obliterated and the capsule reefed in such a way that external rotation is permanently curtailed

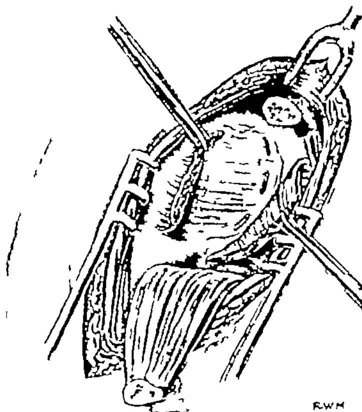


Fig 112
The labrum has been attached to the raw surface on the scapular neck by a series of staples.

Bankart s Operation —Through an anterior incision in the delto-pectoral interval the coracoid process is displayed along with the muscles attached to it namely the coraco-brachialis and the pectoralis minor Division of the process near its tip permits the downward displacement of these muscles and discloses the tendon of subscapularis overlying the front of the joint The tendon is divided in a vertical direction to expose the capsule which is then opened (Fig 111) The detached labrum with or without the adjacent capsular edge is secured to the glenoid margin either by a number of sutures passing through the articular rim or a series of stainless steel staples which are driven into the anterior surface of the scapular neck close by the joint margin (Fig 112)

The operation is concluded by replacement and suture of the sub scapularis approximation of the two parts of the divided coracoid and closure of the wound The arm is kept at the side for two weeks thereafter graduated active movements are begun

Putti Platt Operation —The initial steps are similar but after the subscapular tendon and the capsule have been incised the shoulder is strongly rotated medially and the distal flap of subscapularis is drawn over and stitched down to the soft tissues on the front of the neck of the scapula the medial or proximal flap of capsule is then overlapped and sutured to the front of the lateral flap in the region of the lesser tuberosity of the humerus The after care is on the same lines as after Bankart s operation

CHRONIC PAIN AND STIFFNESS OF THE SHOULDER

Chronic shoulder pain associated with limited movement is a frequent and troublesome orthopædic complaint the uncertain relationship to injury the indifferent results of treatment and the prolonged incapacity to which it gives rise have together contributed to its evil reputation among surgeons

The shoulder is not a particularly strong or stable joint for the articular surfaces are ill-adapted. What security the joint does possess it owes to the strong tendinous reinforcement which the capsule derives from the muscles around the joint especially from the spinati and the subscapularis The tendons of these muscles blend in such a way that they virtually form an unbroken sheet or cuff of tendinous tissue over the anterior superior and posterior aspects of the joint

In more than half the cases of chronic shoulder pain associated with limited movement the explanation is found to lie not in serious intra articular lesions such as arthritis but in a group of more or less minor lesions of these tendons and of the underlying capsule The derangements are sometimes the result of definite injury but often the essential cause is the more subtle trauma of excessive wear and tear The most vulnerable part of the tendinous sheath is the tendon of the supra spinatus which is prone to undergo degenerative changes as a result of friction against the acromion during the movements of abduction and external rotation The tendon may suffer complete or partial rupture while degenerative changes may lead to simple tendinitis or to calcification of the tendon Adhesive or fibrotic changes in the subacromial bursa often coexist

AFFECTIONS OF THE SUPRASPINATUS TENDON

Complete Rupture of the Supraspinatus Tendon.—This generally follows a definite injury such as a fall or a blow on the shoulder it occurs generally after middle age and especially in the heavy manual worker Pain is very severe and there is exquisite tenderness over the greater tuberosity where it may be possible to palpate a distinct sulcus or gap at the site of the rupture The most prominent feature, however,

is a highly characteristic loss of abduction at the shoulder The supraspinatus cannot now fix the head of the humerus and the deltoid in consequence pulls the head upwards to fix it against the acromion a very limited degree of abduction of the arm then occurs by movement of the scapula on the chest wall and active attempts to increase this range simply cause further shrugging of the shoulder

The lesion differs from most tendon ruptures in that retraction of the proximal end is slight it is prevented by the fusion of the supra spinatus with the subscapular and infraspinatus tendons Accordingly if the arm is splinted in a position of abduction and external rotation the gap may be rendered so small that healing readily occurs The splint is retained until the arm can be actively elevated off the support thereafter the arm is gradually brought down to the side active movements being vigorously practised The whole treatment may last as long as two to three months

The alternative treatment is operative repair This shortens the disability period and may be resorted to as soon as the diagnosis is made even in late cases it gives satisfactory results

An anterior vertical incision through the deltoid fibres overlying the tuberosity affords sufficient access It is better not to stitch the proximal end to the insecure fringe of tendon which remains at the tuberosity instead the supraspinatus is firmly fixed by sutures of kangaroo tendon which should be carried through the bone The shoulder is immobilised on an aeroplane splint for three to four weeks until the arm can be voluntarily elevated off the splint Active movements then bring about a rapid restoration of complete function

Partial rupture of supraspinatus is difficult to recognise its effects are an exaggeration of those of simple degenerative tendinitis and the distinguishing feature is a weakening of the power of abduction. Treatment is by rest in an abduction splint, combined with the measures employed in the degenerative type of lesion

Simple Tendinitis—Degenerative necrosis in the supraspinatus tendon combined with changes in the subacromial bursa and possibly with partial tears of the tendon constitutes the largest group of chronic supraspinatus lesions

There is pain over the greater tuberosity and referred along the outer side of the arm The pain is especially felt during the middle range of elevation, when the tendon is compressed against the acromion and there is often a hitch or catch as this part of the movement is carried out When the inflamed' area escapes from contact with the acromion, the terminal stages of elevation are accomplished without pain this is a diagnostic point of great importance As the arm is lowered to the side pain is again experienced and at the angle at which it ceased during elevation a second significant feature from the point of view of diagnosis As a rule there is no restriction of movement unless a small spontaneous rupture has occurred in this event there is some loss of power in elevating the arm Palpation over the point of the shoulder reveals an area of exquisite tenderness but this disappears when the arm is fully elevated and the tuberosity of the humerus has passed beneath the acromion

Serious rupture of the tendon is excluded by the presence of active elevation and arthritis and adhesions by the full range of passive movement calcification in the tendon is differentiated by X ray examination

Mild cases which are encountered with great frequency, often respond to simple measures such as rest in a sling radiant heat or diathermy and light massage In severe cases dramatic relief may be obtained by injecting 10 c c of saline into the tender area after preliminary anæsthesia of the overlying skin with novocaine The injection though immediately successful, is apt to be followed by acute pain within a few hours and the exacerbation may last for a day or two In the initial stage morphia may be necessary to control the great discomfort and the patient should accordingly be put to bed for some hours after the injection the pain is also lessened if the arm is abducted and externally rotated by the simple expedient of tying the hand to the top of the bed After injection radiant heat and massage are employed.

Calcification in the Supraspinatus Tendon —In this lesion calcium salts are deposited amongst the necrotic tendon tissue The deposit may attain a considerable size and in consequence of its very bulk the affected area is subjected to a high degree of pressure against the acromion. In addition, the deposit is held under considerable local tension among the tendon fibres Pain is accordingly more severe than in simple tendinitis and may involve the whole arm

As in tendinitis there is a painful arc between 60° and 100 in the range of abduction, accompanied by the typical catch in carrying out the movement Later muscular spasm is so pronounced that abduction is limited to movement of the scapula on the chest wall and the arm can only be raised to about the horizontal position

Calcifying tendinitis is distinguished from rupture by the absence of the typical powerlessness of the latter condition and by X ray examination, which demonstrates the deposit immediately above the greater tuberosity

Some cases of calcification run a chronic course or after an acute beginning subside to a chronic state which may last some years the symptoms are then correspondingly less severe In the more typical acute cases there is unquestionably a marked tendency to spontaneous cure with absorption of the calcium deposits The pain is relieved with dramatic swiftness by rupture of the tense deposit into the sub acromial bursa and the calcareous matter is absorbed through the agency of the reactionary hyperæmia which the presence of the deposit excites

Two courses are accordingly open to the surgeon He may simply apply palliative measures and await spontaneous cure If this course is selected the shoulder is immobilised on an abduction splint and heat and local massage prescribed The injection of 5 to 10 c c of novocaine or saline may speed the resolution so may a few exposures to X ray therapy

The second course has much to commend it it is more certain

and relief is forthcoming at once It is especially to be recommended when the pain is so severe as to *interfere with sleep or when muscle spasm is extensive* Through a short vertical incision over the tuberosity the deltoid fibres are split The deposit which appears *as a yellowish patch surrounded by a zone of hyperaemia* is then gently curetted out

After operation the arm is immobilised at the side for a few days *thereupon active movements are begun and full use of the joint may be* expected in a matter of four to six weeks

Localised Post traumatic Adhesions

Localised adhesions may form as a sequel to fractures and dislocations of the shoulder joint or simply as a result of immobilisation of the arm in the treatment of more remote lesions such as injuries at the wrist or elbow It should be borne in mind that the violence causing these latter injuries is apt also to contuse the articular surfaces of the shoulder and so predispose to stiffness

The formation of adhesions is more likely in elderly subjects it may then be so pronounced that the limitation of movement is just as severe as in cases of peri-arthritis It is probable that in such cases degenerative tendon and capsular changes have been already present and the injury represents the final insult to the joint

The movements which are greatly restricted by adhesions are those of abduction and external rotation The loss of rotation is especially important in relation to treatment for when the arm is normally elevated above the head external rotation occurs to prevent the greater tuberosity impinging on the acromion The movement is restricted after injury simply because the arm immobilised at the side becomes stiff in internal rotation and there is little use persevering with *abduction exercises unless steps are taken to restore the external* rotation

Adhesions are diagnosed from the inability to raise the arm fully or to place the hand on the back of the head Adduction and forward movements below the horizontal are free and the patient is often able to carry heavy weights without pain

The possibility of adhesion formation should be kept in mind in the treatment of such injuries as Colles fracture regular shoulder exercises and especially abduction and external rotation must be carried out from the beginning This is of course impossible in injuries of the shoulder joint itself

The treatment of adhesions in the first place is by assiduous active movements as at most joints early stretching and early passive movements at their best are without virtue

When improvement ceases—and then only—the question of manipulation has to be considered This should be conducted under anaesthesia and must be gentle the joint is carried once only through its full range of movements Active movements are then instituted and persevered with until function is adequately restored

Peri-arthritis of the Shoulder

This crippling condition resembles a greatly exaggerated form of the previous lesion and is probably due to an extreme degree of degenerative and inflammatory change in the capsule and its tendons with obliteration of the subacromial bursa It generally follows a trivial sprain especially in women over the age of forty, and the striking feature is the gross restriction of movements associated with tenderness not limited to the tuberosity but present over the whole joint The loss of movement is due to the widespread development of firm adhesions in the tissues around the joint and in its most aggravated forms the joint may be quite fixed—the so-called frozen shoulder

Treatment is difficult and may be prolonged The temptation to force movement by passive stretching should be resisted but active movements should be encouraged and assisted by heat and massage Particular attention should again be paid to the restoration of external rotation. It may be some time before improvement is manifest but the tendency in cases of peri-arthritis is towards ultimate recovery

If after some weeks there is no increase in movement the joint may be gently manipulated under full anæsthesia special attention being given to the movements of abduction and external rotation. As the joint is moved the assistant should press his fist into the floor of the axilla to support the head of the humerus and so prevent dislocation If the manipulation is accompanied by the audible breaking of adhesions free active movements may be encouraged at once and the case is likely to do well but if the manipulation takes the form of gradual and difficult stretching against resistance without the rupture of definite adhesions an abduction frame should be applied In such cases there is evidently gross peri-articular fibrosis and the reaction after manipulation is likely to be severe The after-care consists of the active practice of elevation off the splint combined with local heat and massage

RUPTURE OF THE LONG HEAD OF THE BICEPS

The long tendon of the biceps may be the site of spontaneous rupture the tear is situated in the bicipital sulcus and is preceded by degenerative changes in the tendon Necrotic degeneration of the tendon may be secondary to osteo-arthritis of the shoulder joint or may be associated with the general capsular changes of peri-arthritis The diagnosis is made from the history of sharp pain, followed by swelling and later by a palpable gap above the belly of the biceps which is situated at a lower level than normally

The loss of power is often surprisingly slight and operation need not be advised unless the victim is young and the disability is likely to interfere greatly with his employment The ends of the tendon are usually so necrotic that end to-end suture is impossible the alternative methods are either to insert the lower fragment into the humerus in

the neighbourhood of the bicipital groove or to stitch it to the side of the short head of the muscle In either case the gain in function is not notable

ANKYLOSIS OF THE SHOULDER

Ankylosis of the shoulder joint is practically always a fibrous one, it may occur as a sequel to acute or chronic arthritis or sometimes fractures involving the joint surfaces If in good position and the scapula is mobile and well served by active elevating muscles the function of the limb is excellent Unfortunately the ankylosis is often allowed to take place with the arm by the side i e with the humerus adducted and internally rotated and this is a very grave disability Even when the union occurs in a satisfactory position of abduction however the effect of gravity places it at a considerable disadvantage and gradual adduction deformity will occur unless the ankylosis is absolutely sound

A sound ankylosis in good position should be left alone If the position is bad and the ankylosis is bony the best and easiest method of correction is by osteotomy of the humeral shaft at or just below the level of the greater tuberosity In cases of fibrous ankylosis osteotomy is contraindicated because the weight of the arm so frequently leads to recurrence of the deformity In these cases arthrodesis is indicated the position being corrected at operation

If the ankylosis is not sound the joint may be brought into better position by careful abduction under anaesthesia it is then fixed for some months in a plaster spica until the fusion is thought to be firm. At the end of this period active use of the arm may be allowed, and the position of the joint carefully watched If the angle of abduction tends to diminish or if there is pain or muscle spasm further immobilisation is necessary Arthrodesis is in most respects a better and quicker method of converting the unsound into a sound ankylosis than simple fixation

ARTHRODESIS OF THE SHOULDER

Arthrodesis of the scapulo humeral joint in a position of abduction is compatible with excellent function provided the elevator muscles of the scapula are strong and the scapula is freely movable on the chest wall The muscles of chief importance are the upper fibres of trapezius and the serratus anterior

The most frequent indications for arthrodesis are —

1 *Infantile Paralysis* —If the hand and elbow retain a satisfactory or useful range of movement and the scapular muscles are powerful, a flail shoulder or residual paralysis of the deltoid should be treated by arthrodesis

The operation should be carried out reasonably early in childhood —about the age of nine or ten—for the shortening of the arm which results from destruction of the epiphysis is an advantage In adults the question of arthrodesis has to be very carefully weighed The

operation leads to loss of rotation as well as of the other movements, and in women especially this is sometimes considered a disadvantage for they may have come to minimise their disability by trick movements which require passive mobility at the joint

2 *Tuberculosis*—If chest complications are absent arthrodesis of the shoulder joint may be considered in tuberculous arthritis The natural outcome of this disease is a fibrous ankylosis which is very prone to undergo later adduction deformity This can be prevented by sound fusion of the joint Even in the active stage particularly in adults the operation is sometimes indicated in order to shorten the period of disability In late cases it is advisable when the fibrous ankylosis stretches and secondary adduction deformity results

Technique of Arthrodesis—Accurate fitting of the incongruent joint surfaces is difficult to secure and the movements of the chest wall prevent the absolute fixation which favours bony fusion so that special steps must be taken to fix the head of the humerus and the glenoid The operation may be intra-articular or extra articular, or better a combination of the two The following method is recommended

The joint is exposed by a lateral incision which begins in the neck between the clavicle and the scapular space and is continued downwards over the middle of the acromion and in the line of the deltoid for 7 to 8 in The deltoid is split in the line of the incision and each half detached from the margin of the acromion The cortical bone is removed from the upper and lower surfaces of the process which is then retracted upwards after division of its root and fracture of the lateral third of the clavicle

The superior aspect of the joint is now exposed and the biceps tendon is mobilised and retracted and the capsule opened. The joint surfaces are carefully excised and the humerus approximated to the glenoid in the optimum abducted position. An antero posterior gutter is *then cut in the greater tuberosity into this groove the acromion* is turned down and inserted

As a rule it is not necessary to fix the acromion it is held quite securely in place after repair of the deltoid muscle

Immobilisation is best carried out in a plaster spica extending to the waist this is difficult to apply after operation and it is a useful step to put the trunk piece on a day or two before the operation leaving only the easier shoulder piece to be completed at the end of the operation.

Fixation should be continued until there is radiological evidence of sound fusion thereafter a splint is substituted for the plaster and active movements begun to strengthen the scapular muscles The splint is gradually discarded at first for short intervals each day and later for increasing periods until it can be dispensed with entirely

Brittain s method of extra articular arthrodesis is particularly suitable when there is an infective joint lesion such as tuberculosis Through an incision behind the neck of the humerus and the vertebral border of the scapula are exposed and a stout tibial graft inserted between them to act as a strut

EXPOSURE OF THE AXILLARY ARTERY

Exposure of the axillary artery is most likely to be demanded for hæmorrhage in association with wounds, and in such cases the access must be liberal and a good length of the vessel displayed both above and below the injury. Ligation of the artery may also be carried out in the operative treatment of aneurysms of the subclavian or of the brachial artery; the site of election for the application of the ligature is the third part of the artery immediately below its subscapular branch. A large exposure of the actual trunk may occasionally be necessary on account of aneurysm of the artery itself.

Exposure of the Lower Part of the Artery for Ligation.—With the arm abducted and rotated laterally, an incision is made in the line of the vessel from the apex of the axilla downwards. The axillary fascia is incised along the medial edge of the coracobrachialis, and the muscle is retracted laterally along with the musculocutaneous nerve which is seen to enter it. The axillary vessels are enclosed in a prominent sheath within which the vein lies on the medial side of the artery. The median nerve is to the lateral side; the ulnar nerve and the medial cutaneous nerve of the forearm are between the artery and the vein, and the radial and axillary nerves are posterior to the artery.

Exposure of the Upper Part of the Artery.—This operation is practically restricted to cases of aneurysm of the artery itself, or wounds of the vessel. In such cases it is often necessary to display not only the whole course of the axillary artery but the terminal part of the subclavian artery.

The incision consists of a horizontal limb above the clavicle and a second limb which descends from near the medial end of the first across the anterior axillary wall. Through the lower part of the incision the pectoralis major is completely divided; the thoraco-acromial trunk is then secured and the costocoracoid membrane and lesser pectoral muscle cut.

The clavicle is divided close to the edge of the sternomastoid; thereafter the axillary space falls open like a book under the mere weight of the arm, and exposure of the vessel is completed by division of the subclavius.

Repair of the wound is simply effected by suturing the clavicular fragments with wire or kangaroo tendon and approximating the pectoralis major; both steps are facilitated by adduction and medial rotation of the arm.

EXPOSURE OF THE BRACHIAL ARTERY

Exposure of the brachial artery may be required for primary or secondary hæmorrhage in association with wounds. It should be noted that ligation of the brachial artery is often unsuccessful in controlling secondary hæmorrhage from wounds of the forearm, so that occlusion of the radial and ulnar arteries is to be preferred.

The arm is abducted and rotated laterally. In this position it should be supported by an assistant; on no account must it be rested on a

side table for the pressure of the table may be sufficient to push the triceps forward so that it is mistaken for the biceps The artery can be exposed anywhere in the arm through an incision in the line of the vessel overlying the medial edge of the biceps Care must be taken not to place the incision *too far medially* as then the basilic vein may be injured or even the superior ulnar collateral artery and the ulnar nerve mistaken for the brachial artery and median nerve The basilic vein is drawn backwards and medially and the coracobrachialis and

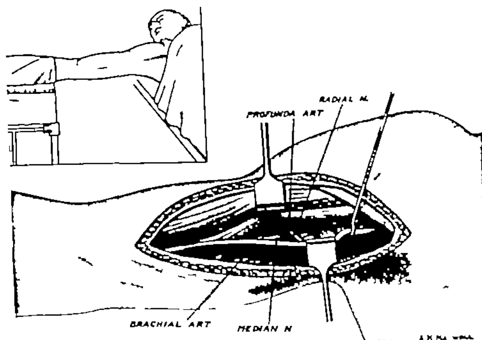


FIG 113
Exposure of brachial and profunda arteries. ("*Surgery of Modern Warfare*")

biceps retracted forwards and outwards to complete the display of the vessel.

The profunda branch can be exposed through the same incision by drawing the brachial artery the basilic vein and the median nerve medially and backwards

EXPOSURE OF THE SHAFT OF THE HUMERUS

Approach to the Whole Length of the Shaft (Henry) —The aim of this operation is to gain extensive access to the humerus without endangering the radial nerve The incision runs from the tip of the coracoid downwards in the line of the cephalic vein to the bend of the elbow and then downwards in the midline of the forearm for a hand s breadth The cephalic vein is retracted and the incision deepened above between the deltoid and the pectoralis major Below the deltoid the brachialis muscle is exposed, with its lateral fourth pro jecting beyond the biceps The brachialis is divided by an incision which slopes backwards and medially to strike the humerus in the middle line the lateral part of the muscle then forms a protective cushion in front of the radial nerve and so protects it from injury

At the lowest part of the incision the division of the brachialis should stop short two finger breadths above the lateral epicondyle but if access to the elbow joint is desired the fibres of the muscle can be split as far as their insertion If the elbow is then flexed to relax the *brachialis the halves of the muscles* can be widely retracted and a good display of the anterior capsule of the elbow is obtained

The shoulder joint can also be readily exposed through a modification of the upper part of Henry s incision A short incision is carried laterally above the clavicle from the upper end of the original incision. *The fibres of the deltoid arising from the clavicle are then detached* along with a flake of bone and this part of the muscle thrown laterally

Limited Approach to the Humerus—A shorter approach to the humerus may be required in fractures osteomyelitis or in growths such as the benign giant cell tumour

Under such circumstances limited access may be obtained by using an appropriate part of Henry s approach or by alternative methods

In the upper part a useful approach especially in osteomyelitis is by the method of Stiles The incision is parallel to the posterior border of the deltoid which is mobilised and retracted to expose the quadrilateral space Through this space the axillary nerve and the posterior circumflex vessels pass backwards in close relation to the surgical neck of the humerus The humerus is free from muscular attachment in front of the lateral head of the triceps and affords the surgeon easy access

The lower end of the humerus is simply exposed through a vertical incision in the posterior midline the fibres of the triceps being split in the line of the skin incision

J B

CHAPTER XVI

AFFECTIONS OF THE ELBOW

Immobilisation of the Elbow Joint

THE optimum position for immobilising the elbow if ankylosis is not expected to develop is acute flexion (25° to 30°) with full supination If ankylosis is expected the position should be suited to individual requirements For most persons the best position is a little below the right angle (100°) which affords a fair reach and permits of buttoning the clothes brushing the hair and using a knife and fork. A more acute angle makes these tasks easier but the advantage is outweighed by the more restricted reach

The elbow is temporarily supported most simply by the collar and cuff sling illustrated in Fig 114 or by a bandage applied as a clove hitch over a wristlet of wool and tied over a pad of wool behind the neck. This method can be applied for most elbow contusions fractures and dislocations as well as after operations in the vicinity of the joint For more complete immobilisation a posterior plaster splint or a complete plaster case should be applied from the shoulder to the wrist



Fig 114

Collar-and cuff sling (*Watson-Jones*)

Exposure of the Elbow Joint

Extensive exposure of the elbow joint is needed in reconstructive procedures such as arthroplasty and excision and less commonly in cases of multiple loose body *formation* The principal methods are —

1 **The Lateral Approach (Kocher s Lateral J Exposure)** —The arm is rested on its *ulnar* border and the elbow joint is slightly flexed the assistant supports it in this *attitude* The incision begins at a point 2 in. above the lateral epicondyle and is continued downwards to the head of the *radius* from here it curves laterally to tail off on the medial aspect of the forearm The cut may be carried down to the bone *without* injuring any significant structure Above the

humerus is reached between the brachioradialis and the radial extensors of the carpus in front and the triceps behind while below the radius and ulna are displayed between the contiguous borders of the anconeus medially and the extensor carpi ulnaris on the lateral side The medial flap comprising the triceps and its insertion into the olecranon, together with the anconeus and the posterior part of the capsule is separated from the bones and reflected medially The radial collateral ligament the extensor origin and the subjacent capsule are then detached from the lateral epicondyle and drawn forwards As a rule the forearm can now be dislocated medially but if more extended access is required the elevation of the medial flap can be continued as far as the medial epicondyle where the ulnar collateral ligament is also erased The ulnar nerve is not endangered if the separation is strictly subperiosteal

2 **The Posterior Approach (Langenbeck)** —In this excellent exposure the triceps is split and separated as two flaps instead of as a single sheet as in the previous method The operation is therefore somewhat *easier than Kocher s exposure*

The incision is placed vertically in the midline, it should be about 4 in long with its centre at the tip of the olecranon. The triceps is divided down to the bone in the line of the incision and deep to it the posterior part of the joint is opened while below the fibrous expansion of the triceps over the olecranon is split The musculotendinous flaps are reflected subperiosteally to the medial and lateral sides until the collateral ligaments are reached If necessary these ligaments can be erased also the ulnar nerve being lifted forwards along with the soft tissues on the medial side

3 **The Anterior Approach (Henry)** —Exposure of the front of the elbow joint is most often demanded for the removal of loose bodies which are most common in the anterior compartment *In osteochondritis dissecans* for example the lesion is invariably situated on the anterosuperior margin of the capitellum and can only be reached from the front

Satisfactory access is obtained by using the lower part of Henry s approach to the humeral shaft (p 287) the joint being reached by splitting the brachialis in the line of its fibres After the brachialis is defined and divided the elbow should be flexed this enables the halves of the muscle to be liberally retracted and affords a good view of the joint

Exposure of the Radius

Exposure of the radius is complicated by its many muscular attachments and coverings The most important of these is the supinator muscle which clothes the upper third of the bone Division of this muscle would of itself be of little significance but the deep branch of the radial nerve (the posterior interosseous) pierces the anterolateral aspect of the muscle high up, and passes obliquely downwards in the substance of the muscle to the back of the limb

Exposure of the head of the radius may be required in cases of fracture with comminution or displacement of the fragments

The incision should be placed well behind the extensor muscles i.e over the ulnar side of the radio humeral joint to avoid any possible damage to the posterior interosseous nerve The bone is reached through the fibres of anconeus and of the orbicular ligament and the entire head should be removed in all cases The rough surface of the neck is smoothed off and Horsley s carbolised bone wax may be rubbed into the raw surface to limit later spur formation The ligament is then repaired by the insertion of a few sutures

Throughout the operation dissection should be reduced to a minimum to avoid additional trauma to the ligaments and muscles otherwise a form of myositis ossificans may occur and prohibit the recovery of satisfactory function

Exposure of the upper two-thirds of the radius may be gained through an incision in the upper part of the line from the lateral epi condyle to Lister s tubercle Access is gained between the radial extensors of the carpus and the common extensor of the fingers a line of separation which is easily recognised owing to the greater mobility of the carpal extensors The supinator muscle is now exposed and may be split care being taken to preserve the posterior interosseous nerve

Exposure of the lower third of the radius may be gained by an incision to the lateral side of the brachioradialis between that muscle and the extensors and abductors of the thumb The superficial branch of the radial nerve must be sought and spared

Arthrodesis of the Elbow

This operation may be carried out when it is desirable to convert an unsound to a sound ankylosis as in quiescent tuberculous arthritis It may also be used when it is necessary to abolish a small range of movement in order to relieve pain as in traumatic osteo-arthritis where there is no tendency to spontaneous ankylosis The advantages of arthrodesis should always be balanced against the advantages of excision or arthroplasty which not only relieve pain but also preserve movement A rarer indication for arthrodesis is flail elbow following infantile paralysis or following wounds with extensive loss of bone

It is difficult to ensure bony ankylosis following arthrodesis of the elbow especially when the articular surfaces are removed and co-aptation of the bone ends is consequently difficult For this reason the articular surfaces should be disturbed as little as possible and fixation secured by supplementary means

The best exposure is by Langenbeck s method and the initial steps are as in excision of the joint Removal of the articular cartilage should be limited and the raw surfaces may be broken up by means of a small osteotome the consequent irregularity of the surfaces favours fusion The head of the radius should be left intact to preserve the rotation movements of the forearm The humerus and ulna are now placed in the optimum position of 100 of flexion, and secured in it by driving a metal pin or better a pair of bone grafts through the olecranon and up into the lower end of the humerus or by carrying a tibial graft from the upper surface of the olecranon to the posterior surface of

the humerus a short way above the joint In the latter method the graft must be well countersunk at each end

Immobilisation in plaster is continued until there is radiological evidence of sound fusion this usually requires at least three months

Excision and Arthroplasty of the Elbow

These two operations do not differ greatly in their scope or object. In arthroplasty the resection of the bone ends is as limited as possible

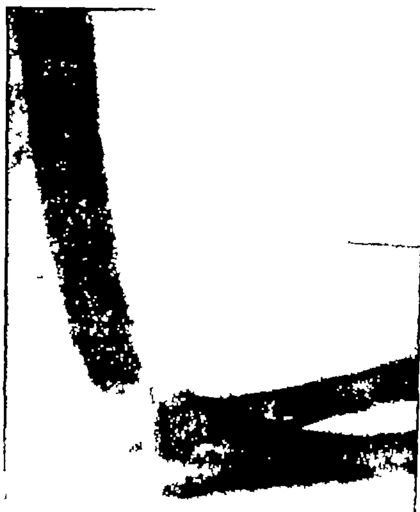


Fig 115

Arthroplasty of the elbow joint performed for loss of movement in traumatic osteo-arthritis.

in order to preserve the maximum stability and an attempt is made to prevent recurrence of the ankylosis by interposing fascia or other foreign substance between the raw surfaces Simple excision of the elbow gives a higher proportion of good results and is more certain this is generally considered enough to outweigh the advantage of the somewhat greater stability after arthroplasty (Fig 115)

Excision.—Either Kocher's or Langenbeck's approach may be used and the dissection is continued until the lower end of the humerus and the upper ends of the radius and ulna are cleared The lower end of the humerus is removed by sawing through the bone immediately below the level of the epicondyles and the upper end of the radius and ulna are resected at the level of the lower aspect of the coronoid process A gap of about 1½ in. should be left between the bone ends when the elbow is extended and the raw surfaces should be liberally smeared with Horsley's wax to limit bone regeneration The soft tissues are then repaired and the elbow placed in the extended position in a Thomas arm splint with slight traction on the forearm The object of this mild pull is to prevent approximation of the cut surfaces and subsequent union After ten days the elbow is gradually brought into the flexed position and supported in a sling until active flexion and extension can be carried out Thereafter active use under supervision is assiduously practised until a useful range of movement is restored

Arthroplasty—A similar method of approach is used in the operation of arthroplasty When the bones are fully displayed the ankylosis is broken down by manipulation or if the fusion is bony by means of a sharp curved osteotome The humerus is dealt with first and a thin shaving of bone is removed by sawing the breadth of the articular surface and roughly its shape being preserved The articular surface of the sigmoid notch of the ulna is next resected as evenly as possible this has the effect of deepening the notch for the reception of the humerus (Fig 115) The head of the radius may be removed in its entirety or its articular surface alone resected A gap of ¾ to 1 in. should now separate the raw surfaces of the humerus and the ulna

The surfaces are rendered as smooth as possible if need be a file being used to remove irregularities and thereafter they may be covered in one of several ways The conventional covering material is a flap of fascia lata from the thigh it is wrapped round the lower end of the humerus which is then replaced in the enlarged sigmoid notch The soft parts should be carefully and accurately replaced and sutured

The elbow is supported in the flexed position in a collar and cuff sling from ten to fourteen days it is then brought down to the right angle and active flexion and extension movements practised

SPRAINS AND CONTUSIONS OF THE ELBOW

Sprains of the elbow joint are more fraught with danger than similar injuries elsewhere and accordingly they deserve special attention The injury is particularly common in children, and the rapid swelling of the joint and the acute tenderness may at first suggest fracture this can however be excluded by radiological examination. If the child is forced to use the joint or worse still if passive movements are carried out a very troublesome stiffness results and it may be months before full movement is restored In some cases myositis ossificans develops and there is even greater interference with function

Contusion of the elbow with effusion into the joint must be treated by two to three weeks immobilisation in a collar-and-cuff sling at

the end of this period the sling should be discarded and a return of function encouraged by supervised active movements Passive movement should never be employed If the child is not seen until some weeks have elapsed and limitation of movement is already present the temptation to carry out manipulation or forcible stretching must be rigidly curbed as the stiffness is thereby only rendered worse Reliance should be placed on the prescription of active and purposeful movements carried out under the supervision of a trained and restrained masseuse

ACUTE ARTHRITIS OF THE ELBOW

This is not common apart from infected wounds In general it is treated on the lines already indicated (p 101) In the early stages immobilisation is most easily secured by the use of a posterior plaster slab extending from the shoulder to the wrist with the elbow in the optimum functional position

Aspiration of the Elbow Joint.—The contents of the elbow joint are most easily withdrawn if the needle is introduced immediately above the head of the radius from behind with the joint flexed and the forearm semi pronated

Open Drainage of the Elbow—If drainage becomes necessary the joint should be opened from behind The incision is made on one or both sides of the olecranon and prolonged upwards for about 3 in The subsequent approach is along the medial and the lateral margins of the triceps aponeurosis and on the medial side the ulnar nerve must not be injured

Drainage is improved when the elbow is flexed and the joint should again be bandaged or splinted in the optimum position

CHRONIC ARTHRITIS OF THE ELBOW

This is a common sequel to certain intra articular fractures—for example the intercondylar or Y shaped fracture—and to long employment in certain trades such as mining and carpentry

The radiological appearance of the joint may at first sight seem appalling gross lipping may be added to deformity of the articular surfaces and paracondylar ossifications and loose bodies may be present Too much attention should not be paid to such findings, for the function of the elbow *joint is often remarkably good*

Treatment in the elderly should be primarily conservative by counter irritation heat and rest in a sling or right angled plaster cast as in other joints this may tide the patient over the acute attacks

In the young person and especially in the chronic arthritis which follows fracture an arthrodesis or an excision or arthroplasty should be strongly urged.

ANKYLOSIS OF THE ELBOW

Bony Ankylosis.—If the joint is in good position *i.e* about 100 of flexion and semi pronation then it should not be lightly interfered

with unless a movable joint is demanded by the patient or rendered desirable by the nature of his occupation or unless the joint of the opposite side is also ankylosed In this event a mobilising operation may be undertaken in the shape of formal arthroplasty or, more simply of excision of the joint It should be pointed out to the patient that mobilisation implies some loss of stability in practice the artisan will generally speaking be better served by his ankylosis whereas both women and men who do not use their arms for manual labour may derive considerable benefit from arthroplasty (Fig 115) When the upper end of the radius is involved in the ankylosis excision of the radial head may restore to a varying degree the rotary movements of the forearm This alone may give the patient a sense of increased freedom of movement without the necessity of operation on the elbow joint proper

If the joint is in bad position correction of the deformity is essential It may be obtained by simple osteotomy of the lower end of the humerus with correction of alignment or since operation is necessary in any case an attempt may be made to restore mobility

Fibrous Ankylosis.—This form of ankylosis is seen after tuberculous arthritis and acute pyogenic arthritis If the ankylosis is sound *i e* solid and unyielding the patient is just as well off as with a bony ankylosis and operative treatment should not be adopted unless under the circumstances indicated above If the ankylosis is unsound *i.e.* not proof against further deformity then prolonged fixation in a splint or plaster is indicated Alternatively provided the active inflammatory stage of the disease is passed, an attempt may be made to create a movable joint by arthroplasty or excision (Fig 115)

MYOSITIS OSSIFICANS AT THE ELBOW

Ossification may occur in the fibrous tissue of the brachialis or less commonly the triceps muscles as a result of injury and particularly of dislocation. It is due to tearing of the periosteum and is favoured by inadequate immobilisation of the injured part and by over enthusiastic massage and pump-handle movements These well intentioned measures cause repeated dragging on the torn periosteum which is thus given no chance to heal.

Myositis ossificans is more frequent in childhood and in the brachialis anticus In extreme cases the new bone may extend from origin to insertion of the muscle so that the elbow is completely fixed More commonly the ossification is partial, and there is a mass of bony tissue which limits flexion at the joint to about a right angle

Injuries to the elbow liable to be complicated by myositis ossificans should be immobilised for three weeks at the end of this time active movements only are begun. Massage and in particular passive movements are contraindicated

Myositis is suspected if after temporary improvement the range of movement fails to increase Its presence is then confirmed by radiological examination No special treatment is required it is

unnecessary and even wrong to immobilise the joint completely Active movements by the patient are harmless but *passive stretching and massage must never be employed*

In the majority of cases the bony mass is gradually absorbed over a period of some months If this does not occur operative removal may be undertaken but only if the bone is well consolidated has not grown in size for several months and is actually causing disablement Operation in the early stages is absolutely contraindicated since the *trauma of the operation induces recurrence*

VOLKMANN'S CONTRACTURE

Volkmann's contracture which generally occurs as a complication of supracondylar fracture of the humerus or other injuries in the vicinity of the elbow is now believed to result from arterial obstruction Often

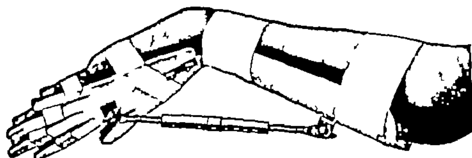


FIG 116

Splint for correction of Volkmann's contracture ("Surgery of Modern Warfare")

the brachial artery is contused or lacerated and thrown into acute spasm and the distal collateral vessels may be constricted by reflex spasm originating in impulses from the traumatised segment of the main vessel

Since an established contracture is very disabling prevention is of especial importance

Prevention—In any case of injury in the elbow region in which the radial pulse is small or absent or becomes so after fixation and in any case in which pain persists or coldness or lividity of the fingers develops the possibility of Volkmann's contracture must be remembered and urgent steps taken to prevent its development

The fracture must be reduced without delay If the signs persist or only *appear after reduction and fixation splints and bandages* must be removed immediately and the elbow lowered to a right angle The limb should not be elevated as this tends to increase the vascular spasm The other arm or leg may be immersed in hot water with the object of inducing reflex vasodilation

If the circulation has not improved within two or three hours an attempt may be made to relieve the spasm of the collateral vessels by *the injection of a local anaesthetic into the stellate* and upper thoracic ganglia of the sympathetic trunk If this is unsuccessful the brachial artery should be exposed by operation gently mobilised and released

from any contact with the fracture surfaces When the vessel is not actually damaged this may suffice to restore the circulation but if the vessel remains pulseless and contracted the affected segment should be removed between ligatures (arteriectomy) with the object of releasing the reflex constriction of collateral vessels

The operation is only likely to be successful within twelve hours of the onset of the ischæmia

Treatment.—The most useful method of treating the established contracture is by gradual stretching It depends on the fact that the degree of flexion contracture at the wrist is not extreme and if this joint is placed in the fully flexed position the fingers can be more or less straightened out Individual finger splints are therefore applied with the wrist held in flexion by a malleable splint The wrist is then gradually extended over a period of weeks until it is brought into a position of dorsiflexion At this stage the splints are removed daily for massage and exercises later they are discarded during the day but reapplied at night If supplemented by faradism and other physiotherapeutic measures this method restores as much function as remains in the undamaged muscle fibres secures the wrist in the position in which that function will be most useful and improves the appearance of the hand and fingers

Many operative measures have been suggested these however offer even less prospect of improving function than the conservative stretching method. The most useful of the operations is the muscle slide operation of Max Page in which the flexor muscles are detached from the medial epicondyle and from the radius ulna and interosseous membrane and allowed to assume new attachments more distally in the forearm The operation should only be undertaken when flexion of the elbow and pronation of the forearm are marked and to obtain the maximal correction even of these deformities the anterior capsule of the elbow joint and the pronator teres muscle may both have to be divided (Griffiths)

Operation may also have to be undertaken for the relief of nerve paralysis by neurolysis especially in the case of the median nerve which is liable to be strangled between the heads of pronator teres

In late cases the appearance may be improved, and if movement of the fingers is present the function also aided by excision of the *carpus* This shortens the distance between the original attachments of the contracted muscles and allows the wrist to assume the optimum position of dorsiflexion

TENNIS ELBOW

The term tennis elbow' or epicondylitis is applied to a crippling pain on the lateral aspect of the elbow at or below the lateral epicondyle The causal pathology probably varies but only a small proportion result from tennis or similar games Any activity involving firm gripping with the hand and repeated rotary or flexion-extension movements of the elbow may give rise to it

In some cases the onset is sudden and the disability severe from

the first Tenderness is located over the radio-humeral joint and it is more than likely that the lesion is an intra-articular one, possibly of the nature of a nipped synovial fringe

In this type early manipulation may produce a dramatic cure, but if the early opportunity is lost the joint may have to be rested, and partially immobilised by strapping applied fairly tightly from the middle of the upper arm to the wrist with the elbow in the flexed position

In many cases the onset is gradual and symptoms are only present when the arm is in use The area of tenderness is now over the epicondyle or just below it and the pathological lesion is believed to be extra-articular Sprain of the upper part of the lateral ligament a partial tear of the common extensor origin or periostitis of the lateral epicondyle are usually blamed Traumatic inflammation of a bursa beneath the common extensor origin has been held to explain some cases (Osgood) but even at operation it is impossible to define this bursa

In the extra articular type early manipulation is not indicated. The joint should be rested and strapped and activities productive of pain forbidden or restricted Short-wave diathermy novocaine infiltration and massage may be helpful if the tenderness is very localised, but such measures are often disappointing and the condition may take months to subside

Manipulation may be useful in the late stages when localised persistent tenderness or pain on carrying out a particular movement suggests the presence of an adhesion

The standard manipulation for tennis elbow is that of Mills The wrist is fully flexed the forearm pronated strongly and finally the elbow is quickly forced into full extension After the manipulation free use of the arm is encouraged and heat or diathermy may be applied to hasten recovery In many cases the effects of the first stretching are not wholly successful but the procedure may be repeated at short intervals until complete relief is obtained

If in spite of rest manipulation and physiotherapy the symptoms persist for an undue length of time or are very severe, or recur after apparent recovery it is justifiable to resort to operation The operation consists essentially of the erasion of the common extensor aponeurosis from the epicondyle It can be gently and easily accomplished through a short incision under local anaesthesia the fibres being simply elevated from the bone by means of a sharp periosteal separator or the tender area may be completely excised

OLECRANON BURSITIS

Acute or chronic inflammation of the bursa between the upper end of the ulna and the triceps aponeurotic expansion is of frequent occurrence The acute variety is important in so far as its close relation to bone may lead to a complicating osteitis and the tension under which the inflammatory products are contained favour necrosis of the overlying fascia, and spread of the infection as a cellulitis of the upper

part of the forearm If therefore the infection does not quickly respond to aspiration and penicillin therapy the bursa should be drained by incisions at its lateral and medial borders

Traumatic enlargement of the olecranon bursa (miner s elbow student s elbow) may initially respond to aspiration and strapping but if the swelling recurs and persists the sac should be dissected out The incision should be a curved one with the convexity of the curve upwards or a hockey stick incision beginning proximally and skirting the upper and lateral borders of the bursa in this way the scar is not on the part of the elbow used in leaning

J B

CHAPTER XVII

AFFECTIONS OF THE HAND

THE surgery of the hand demands a high standard of diagnostic and technical skill. The operative field is restricted and a faulty incision or post-operative infection may lead to prolonged or permanent disability. It follows that the treatment of most hand affections and especially injuries should be conducted only in hospitals where theatre facilities are available and where asepsis is assured. *In particular the re-dressing of hand wounds must be conducted with a full aseptic ritual*; even in septic lesions this rule must be observed, for mixed infection is prone to occur and is peculiarly destructive.

Adequate anæsthesia and the use of a tourniquet are essential to sound technique, for an alarmed patient and an operative field obscured by blood conspire to induce haste and uncertainty.

Anæsthesia.—General anæsthesia is to be preferred in most cases, and *is essential in the treatment of hand infections*. It has the advantages of obviating the discomfort of the tourniquet and of allowing the surgeon to work with deliberate care.

Regional anæsthesia and nerve block may be used in the absence of infection, but are usually less satisfactory. *Regional anæsthesia* is an advantage in locating foreign bodies in the palm, for the anæsthetic solution distends the tissues and renders them translucent. *The palmar infiltration* should not begin by injection through the thick and sensitive palmar skin. The initial injection of 1 per cent. novocaine is made on the dorsum and deepened between the metacarpal bones to the subcutaneous palmar tissues and to the palmar dermis where an intradermal wheal is formed. This point is used for the subsequent infiltration of the remainder of the palmar tissues. *Anæsthesia of a finger* by nerve block is conveniently carried out by infiltrating novocaine in a ring round the base of the finger. The injection is begun on the dorsum where the skin is less sensitive. Adrenaline should not be added to the novocaine solution because there is some evidence that this has contributed to the occurrence of gangrene. *Anæsthesia of the whole hand* can be induced by blocking the nerve trunks at the wrist. An injection of 5 c.c. of 2 per cent. novocaine is made to the radial side of, and deep to, the tendon of flexor carpi ulnaris immediately above the pisiform to block the ulnar nerve. A similar injection is made from a point on the ulnar side of palmaris longus in a direction obliquely towards the radial side to block the median nerve. Finally the subcutaneous tissues of the wrist are infiltrated in a complete

ring to block the superficial nerves The method of infiltrating the edges of an accidental wound is best avoided If general anæsthesia is not feasible a nerve block at the wrist should be used

Tourniquet.—A tourniquet should be used in most operations on the hand A pneumatic tourniquet or the cuff of a sphygmomanometer is more convenient than an ordinary tourniquet and diminishes the risk of radial nerve palsy This risk is greatest in women with thin arms and in such patients the tourniquet should be applied to the upper part of the forearm in preference to the arm A practical point worth noting is that pneumatic tourniquets tend to cause venous congestion because inflation leads to collapse of the veins before arterial flow is arrested This can be avoided by firmly bandaging the limb with an Esmarch bandage from the fingers to a point beyond the site of application of the pneumatic cuff The cuff is then strapped in position inflated to a pressure of 250 mm of mercury and the Esmarch bandage removed For operations on the distal parts of the fingers hæmostasis can be secured by a rubber band drawn tightly round the base of the finger and clamped by artery forceps

Incisions in the Hand and Fingers.—In the deliberate surgery of the hand the incision must be carefully planned so that the resulting scar will not be a source of disability Care is particularly necessary in draining abscesses and the principle that abscesses should be opened by the most direct route has few applications in the hand Suitable incisions are fully described in the text but it is necessary here to condemn several incisions which though well known to be faulty are still much used by inexperienced surgeons

At the tip of the finger an incision in the midline is bad On the palmar aspect it injures the most sensitive part and in view of the anatomical arrangement of the fibrous septa it affords neither good drainage nor satisfactory exposure On the dorsal aspect incisions in the midline of the nail and nail fold damage the nail and the matrix and lead to unsightly ridging

The horseshoe or so-called fish mouth incision in the pulp is bad The flap inevitably contracts and results in an ugly depressed scar

At the nail fold incisions for drainage which do not open the lateral gutter are unsatisfactory because they lead to the development of chronic paronychia

In the remainder of the finger incisions in the midline should be avoided Palmar incisions tend to cause flexion contracture and favour prolapse of the tendon while dorsal incisions hinder subsequent flexion Anterolateral incisions often recommended for tenosynovitis are also dangerous because they jeopardise the digital vessels and nerves

Incisions which pass from the palm to a finger across the flexion crease frequently result in a contracted scar and in flexion deformity of the finger Similarly movement may be hampered by an incision across the web of the thumb

Incisions in the thenar eminence must not extend proximally beyond a point 1 in distal to the lowest flexion crease at the wrist otherwise the important motor branch of the median nerve may be

divided with subsequent paralysis of the short muscles of the thumb

Immobilisation —The principle of rest for injured tissues is as important in the hand as elsewhere but *the position in which the hand is to be immobilised must be carefully chosen* if prolonged stiffness of the joints is to be avoided. In the position of rest even prolonged immobilisation does not cause permanent stiffness provided the joints have escaped injury and infection When the joints are diseased and stiffness is inevitable the position of rest should be maintained, because it is also the position of optimum function

The fingers should be immobilised in a position of slight flexion *at all the joints—never in full extension* which relaxes the collateral ligaments and allows them to become contracted The normal concavity of the palm should be maintained by holding forward the first and the fifth metacarpals and the muscles of the thenar and hypothenar eminences should not be pressed upon by the splint The *wrist should be in 20° to 30° dorsiflexion* Finally if there is any danger of the distal radio-ulnar joint becoming involved by infection the wrist should be in 30 pronation from the mid position—greater pronation causes difficulty in dining and greater supination causes difficulty in picking up small objects Plaster of Paris splintage is the only method of readily maintaining these positions A moulded anterior plaster slab can accommodate the fingers in a series of troughs maintain the concavity of the palm without pressing on the muscles *and keep the wrist in the cock up or dorsiflexed position of election*

TREATMENT OF INFECTIONS OF THE HAND AND FINGERS

General Principles.—Chemotherapy—and notably penicillin—has greatly reduced the seriousness of hand and finger *infections* If employed sufficiently early a large number of infections may be expected to resolve and many others to remain localised while the systemic effects of the infection are controlled As in other situations however penicillin is not to be regarded as a substitute for surgery pus must be evacuated when it forms and tension must be relieved

Early and accurate diagnosis not only of the infection but *of its exact site and extent is essential* for efficient surgical care Fortunately in most cases this is easy if the clinical evidences are properly interpreted in the light of the careful anatomical studies of the past few years Incisions must be planned with due regard to the safety of nerves vessels and uninfected tissues while ensuring efficient drainage They must on no account increase the disability hence localisation of the suppurative process must be very discriminating Operations should be carried out under general anaesthesia with a *pneumatic tourniquet on the arm*

After-care —The widespread use of hot wet dressings is to be condemned Such dressings are painful and they cause a sodden swollen condition of the wound and surrounding tissues which both interferes with drainage and makes local spread difficult to recognise Too

frequently repeated dressings also increase the danger of secondary infection.

Local penicillin applications have no especial virtue, save in the very superficial infections such as paronychia in which a penicillin cream is useful In the deeper infections the drug should be used systemically and after incision the wound is covered with a sterile vaseline gauze swab and a minimum of dressing applied The dressing should as far as possible be confined to the infected part—in the case of a finger for example the other digits should be left quite free, so that they can be exercised from the very start On return to bed the hand should be elevated This is most easily done by applying a dorsal splint of Cramer wire from below the elbow to the end of the fingers and then suspending the splint to a bedside stand with the elbow flexed

If the local condition is satisfactory and pain and fever are relieved the wound need not be dressed for three to four days At the end of this period the second dressing is carried out with full aseptic precautions The vaseline gauze is removed, and the wound irrigated with saline to get rid of sloughs If an infra red or radiant heat lamp is available the wound should then be covered with a sterile swab and exposed to the lamp for fifteen to thirty minutes during the whole period movements of the fingers are practised assiduously A further vaseline gauze covering is applied if the condition of the wound warrants it and the part again bandaged In certain infections—pulp infection and subcutaneous infection of the fingers particularly—it will be possible to use a plaster cast instead of a bandage exactly as in the Winnett-Orr after treatment of osteomyelitis This method has the great advantage that it allows the other fingers to be vigorously exercised The plaster is removed and the second dressing carried out after a week In successful cases the wound will then be healed or well on the way to healing and further dressings are applied or omitted according to circumstances It is worth emphasising that the most potent cause of delayed healing, as well as of secondary infection is too frequent dressing next in frequency is the use of antiseptics such as flavine carbolic, or mercuric preparations The only antiseptic which may be required is eusol or Dakin's solution this is useful in cases in which there is much sloughing in the wound

Lymphangitis of the Fingers and Hand

Lymphangitis commonly follows a puncture wound, especially in the pulp of the finger The infection may spread rapidly up the hand and forearm to the regional glands or into the blood stream

The usual organism is a streptococcus and the majority of cases resolve completely under the influence of a course of penicillin administered systemically Less often as the infection is overcome local abscesses occur at the site of inoculation, in the subcutaneous tissue of the dorsum of the hand on the volar aspect of the forearm in one of the fascial spaces of the hand, or in the epitrochlear or axillary glands

The initial treatment of lymphangitis is to apply heat to induce Bier's congestion and to institute intramuscular penicillin therapy combined possibly with a sulphonamide preparation by mouth.

Local heat is applied to the part by foments antiphlogistine or kaolin or by radiant heat lamp Bier's congestion is induced by means of a pneumatic tourniquet or the arm cuff of a sphygmomanometer inflated just sufficiently to cause cyanosis and slight swelling without increasing the pain or the discomfort The congestion is maintained for periods of four hours at a time with breaks of half an hour

Under this régime many cases will resolve within two to three days As the violence of the infection subsides a careful watch is kept for the development of suppurative lesions these are treated on the lines indicated below

Acute fulminating lymphangitis almost merits being considered a disease entirely on its own After the initial infected prick wound there is a short incubation period followed by rapidly spreading swelling and redness Widespread induration of the subcutaneous tissues occurs with superficial blisters filled with grey watery pus or with patches of dirty gangrenous sloughs The septicæmia is profound and the majority of such cases—which are fortunately rare—were at one time fatal in a matter of days

In the treatment of such infections chemotherapy holds out practically the only hope of success Incisions are made when and where they are required It is in this class of case that dramatic amputations were sometimes undertaken in an effort to stay the progress of the blood infection How far such desperate measures were ever justified is a matter of doubt but it is certain now that penicillin has rendered them obsolete

Infections about the Nail

Paronychia.—Infection—usually staphylococcal—in the nail fold is one of the commonest forms of whitlow The pus fills up the nail fold and then extends distally beneath the root of the nail which is thus lifted from its bed

In most cases the infection can be aborted by the use of systemic penicillin if treatment is begun before suppuration is established

In later cases where there is an abscess in the nail fold drainage by incision is necessary Incisions are made from a point immediately distal to the junction of the nail fold and the lateral sulcus on each side The rectangular flap so outlined is reflected upwards and pus evacuated A vaseline gauze strip is laid from side to side under the flap which is then allowed to fall back into place (Fig 117) If there is a collection of pus under the nail the base of the nail is removed by means of a pair of fine-pointed scissors after the flap is reflected Trephining—the removel of a small window or separated nail—seldom provides satisfactory drainage on the other hand removal of the whole nail is not indicated except in neglected cases in which the infection has overrun the entire nail bed

The dressing is left undisturbed for a few days then the gauze drain

is removed and a dry dressing applied over a tulle-gras cover Healing is usually complete at the subsequent redressing in four to five days

Chronic Paronychia.—Paronychia has an unfortunate tendency to become chronic The nail fold is then indolently swollen, glazed and bluish red in colour exuberant granulations sprout from under the fold the nail is often deformed and raised from its bed and there is a chronic slight purulent discharge The cause of chronic paronychia is either inadequate initial drainage or improper after-care—especially the continued use of wet antiseptic dressings



(1) (2) (3)

Fig 117

Paronychia (1) the incision (2) flap turned down and base of nail removed (3) gauze pack inserted.

The nail fold should be reflected as in acute cases The granulations are lightly curetted, and the base of the nail clipped away as freely as necessary Even in chronic cases removal of the nail in its entirety should be avoided since the remaining part affords protection to the sensitive bed Local penicillin dressings are then used until healing is assured.

Onychia (Subungual Whitlow)—In this important but rare form of infection a small abscess forms under the epidermis of the nail bed at the finger tip It is both exceedingly painful and potentially serious for the pus may track to involve the bone or the pulp of the distal phalanx The lesion should be opened by a short incision near to and parallel to the free edge of the nail After the pus is evacuated it will be found that the dorsal wall of the abscess is formed by the thin epidermis of the nail bed and this should be excised along with a small triangular piece of the nail-edge

The Pulp Infection

The pulp infection is a localised suppuration in the subcutaneous tissues or pulp of the terminal phalanx and it owes its special significance to the peculiar anatomical arrangements obtaining in this area In the distal part of the pulp a series of fibrous septa passes from the skin to the periosteum and the space is thus converted into a number of loculi which are difficult to drain adequately in acute infections A rapid rise of tension in the confined space commonly leads to occlusion of the blood vessels and necrosis of the bone and the soft tissues results The base of the phalanx always escapes however for it is supplied by separate branches arising from the digital arteries before they enter the dangerous area

The usual cause of pulp infection is a prick from an infected object such as a needle or a fish bone and the commonest infecting organisms are the staphylococcus and the streptococcus In view of the rapid

rise in tension pain and swelling are early and pronounced and if there is not a speedy response to intramuscular penicillin the tension should be relieved by incision It is sometimes difficult in the case of manual workers to decide when pus has formed A useful clinical rule is to incise the pulp if the patient has passed a *completely sleepless* night on account of pain

The incision must open all the infected loculi and provide free exit for the inflammatory products A midline incision can never do this furthermore it lies on the sensitive tactile part of the finger and if it is prolonged too far proximally it endangers the tendon sheath Nevertheless it is permissible to enlarge a central sinus already established in neglected cases for preliminary exploration and to clip away the *epidermis over a purulent subcuticular blister* overlying a central communication with the pulp space The horseshoe or fish mouth incision sometimes recommended affords ideal drainage but since the flap tends to shrink a broad and depressed scar results

The best incision in the absence of sinuses is one placed on the lateral *aspect of the phalanx and the scalpel is passed across the whole* breadth of the pulp on the volar aspect of the bone so as to divide all the fibrous septa close to their periosteal attachments Pus is evacuated and all obviously necrotic soft tissue should be removed If the swelling is great a second lateral incision should be made on the opposite side A drain of vaseline gauze is then pulled through from side to side and a simple dry dressing applied The gauze drain should be removed in forty-eight hours and vaseline or paraffin dressings are continued or *the whole finger is enclosed in a plaster of Paris cast*

If the bone appears to be involved at the time of operation no attempt should be made either to scrape it or to remove it It is impossible to forecast the extent of the ultimate necrosis which is often much less than would appear probable further diaphysectomy *deprives the soft tissues of their support* and retraction and shrinking occur leaving a flat and ugly pulp Treatment should be the same as for cases without bone involvement but in the post-operative period a careful radiological check is maintained At first there is often some decalcification and surface irregularity but necrosis does not always follow If a sequestrum develops treatment should be delayed until it is completely separated The incision is then enlarged and the loose fragment picked out

The Purulent Blister

This may be due to a *superficial infection of the epidermis,* but often results from spread from a deeper collection of pus

The raised epidermis is cut away in its entirety and search is then made for a deep collection of pus If the communicating hole is adequate no additional drainage is required if not it should be *enlarged by cutting down on a probe*

A vaseline or a penicillin cream dressing is applied and then a plaster cast This type of infection gives particularly good results from the closed plaster method provided *adequate drainage* is obtained

Subcutaneous Infection (Cellulitis) of the Finger

Cellulitis unlike pulp lesions has practically no tendency to involve the bones but occasionally it gives rise to secondary tenosynovitis and in neglected cases there may be sloughing of the skin overlying the suppurating focus The infection first spreads in the volar subcutaneous tissues of one phalanx extension to the dorsum is prevented by adhesion of the skin to the deep tissues at the side of the phalanx but ultimately the pus spreads to the cellular compartment of the adjacent phalanx or upwards to the base of the finger and an abscess forms in the appropriate half of the web

If drainage becomes necessary incisions are made on each side of the finger in front of the plane of the digital vessels and nerve over the whole length of the phalanx If the area of infection embraces both phalanges separate incisions are made opposite each space and the skin opposite the joint is left intact

If an abscess is found in the web only a single lateral incision should be made and carried upwards to divide the web close to the finger Pus is evacuated and the edges of the wound kept open by a slip of rubber dam or by a wick of paraffin gauze If drainage has been adequate as indicated by the absence of pain the wound need not be disturbed for two or three days The drain is then removed and the wound redressed the dressing being repeated every few days until healing is evident

Suppurative Tenosynovitis

Suppuration in the flexor tendon sheaths though rare is the most grave of all the forms of hand infection for necrosis of the tendon commonly occurs the sloughs are slow to separate suppurative arthritis of the interphalangeal joints may develop the infection may rupture into the palmar spaces or the forearm and prolonged or permanent disablement often results

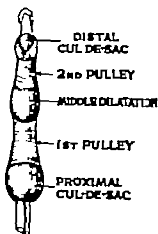


Fig 118

Digital tendon sheath showing distended cul-de-sac proximal to first pulley ("Surgery of Modern Warfare")

It is in this type of infection that penicillin has proved most valuable combined with surgery to relieve the tension in the sheath and to allow of local penicillin application systemic penicillin should control the infection and healing should occur with substantial preservation of function in the affected finger

Streptococci disappear from the infected sheath in forty-eight hours but it may be a week or more before staphylococci are eliminated completely It is important therefore to continue the administration of the penicillin for at least ten days

Index, Middle, and Ring Fingers—Here the digital sheaths end proximally at the level of the distal palmar crease in a pronounced cul-de-sac which very early in the infection becomes distended with pus (Fig 118) If the tension is not relieved it is here that rupture takes place pus escaping into the deep fascial space of the palm

In early cases it may be sufficient to expose the proximal cul-de-sac by an incision in the web which can be prolonged on to the lateral aspect of the proximal phalanx The infected sheath bulges and a small incision is made into it when the pus is evacuated 20 000 units of penicillin in 1 c c of saline are injected and the wound drained by dental rubber or by a gauze wick In later cases and when these simpler measures fail it is usually necessary to make further incisions on the lateral aspects of the phalanges they should not transgress the interphalangeal joint

Thumb and Little Finger—Here the digital sheaths communicate respectively with the radial and ulnar bursæ in the palm and these may intercommunicate

It is a rare event since the introduction of penicillin for infection to extend from the digital sheaths to the palmar bursæ and suppurative tenosynovitis of the thumb or little finger usually responds to drainage and penicillin instillation through an incision along the lateral side of the proximal phalanx of the thumb and along the ulnar side of the proximal or proximal and second phalanges of the little finger

If bursal infection should supervene a director should be passed proximally from the digital wound and an incision made on to its point in the palm or above the transverse carpal ligament With care, and in a bloodless field this can be accomplished without damage to other structures and after the pus escapes penicillin should be introduced and the wound drained as usual

Necrosis of the Tendon.—Continued tension within the sheath may lead to necrosis of the tendon from loss of its blood supply In this event suppuration is prolonged and continues until the dead tendon is sloughed off The end result is likely to be a stiff and useless finger and in the meantime the function of the rest of the hand may be seriously imperilled

If the tendon is found to be sloughing at the original operation or at subsequent re-exploration it is often wiser to proceed to disarticulation of the finger at the metacarpo phalangeal joint without more ado An exception must be made in the case of the thumb which must be preserved at all costs since even a completely stiff thumb is invaluable The sloughing tendons are therefore cut away and free drainage provided The thumb is immobilised in a position of function and the other fingers left unencumbered by dressings so that their function can be encouraged from the start

Involvement of Joints.—Infection may spread from a tendon sheath to one of the digital joints especially the proximal interphalangeal joint Rapid disorganisation takes place and since permanent disablement is certain it is best to proceed at once to disarticulation

Infection of the Fascial Spaces

Middle Palmar Space—This space which lies deep to the flexor tendons and in front of the lateral three metacarpals is generally infected from the tendon sheath of the middle or ring finger It is drained most effectively through an incision in the distal part of the fourth interspace carried down to the free edge of the web In severe cases a further incision may be made in the third interspace

Thenar Space—This space which lies deep to the flexor tendon of the index and in front of the adductor pollicis may be infected from the tendon sheath of the thumb or index finger It is best drained through a dorsal incision through the web parallel to the index meta carpal In severe cases a counter incision may be made in front by cutting down on a probe

Parona's Space.—This space which lies in the forearm behind the common flexor sheaths and in front of the radius and ulna and the pronator quadratus is directly continuous with the deep palmar spaces and may be infected from them or from the flexor sheaths

It is opened by an incision about 3 cm. above the ulnar styloid process on the medial side of the forearm A counter incision may be made on the lateral side by cutting down on a probe

TUBERCULOUS TENOSYNOVITIS

The most frequent site for tuberculous tenosynovitis is the common flexor sheath.

The disease is surprisingly amenable to surgical interference since it rarely displays any tendency to caseation or cold abscess formation. The operation is by no means an easy one however In the commonest pathological variety the visceral layer of the synovium is replaced by granulation tissue which clothes and encompasses the tendons and produces a matted bundle of tendon and inflammatory tissue In such cases the surgeon must be prepared for a long and tedious opera tion which involves dissection and clearing of the individual tendons these are often attenuated and their definition and disentanglement demand great care and patience In a less common variety the sheath is greatly thickened and distended with fluid containing melon-seed bodies the removal of this type is easier

The incision is vertical from a point an inch above the proximal crease of the wrist to the level of the web of the outstretched thumb The palmaris longus is detached and the transverse carpal ligament divided. Thereafter the flexor carpi radialis tendon and the median nerve are defined and drawn laterally and the common flexor sheath is opened. The tuberculous granulation tissue is then cleanly dissected off each tendon. The transverse carpal ligament should be carefully repaired and the wrist immobilised for ten days in a dorsiflexion plaster or splint Movements are begun at the end of this period

GANGLION OF THE WRIST

The neighbourhood of the wrist is one of the most common situations for ganglion On the dorsum it may be attached to the joint capsule between the lunate and the scaphoid or between the capitate and the multangulum major or it may arise in the sheath of the radial carpal extensors and grow outwards between the extensor pollicis longus and the extensor digitorum tendons On the volar aspect the most frequent site is between the flexor carpi radialis and the brachio-radialis close by the radial artery

Rupture of a ganglion by firm digital pressure and dispersal of the fluid into the surrounding tissues by massage is sometimes followed by cure and injection into the swelling of a few cubic centimetres of hyaluronidase (hyalase) is also frequently curative

If these simpler measures fail or if the ganglion recurs, it should be excised Incomplete operations are very liable to be followed by recurrence and in view of this and the close relationship of the cyst to the joint or tendon sheath dissection in a bloodless field is essential and general anaesthesia desirable The incision should be fairly generous, and is placed over the swelling The wall of the ganglion is displayed by carefully deepening the incision through the deep fascia in the process a watch should be kept for superficial nerves which have become adherent to the swelling and if any are discovered they should be freed and retracted

The deeper limits of the cyst are defined by dissection as it is not usually possible to shell it out and as the separation proceeds the tendons and the sheaths must be cleared and gently drawn aside Drainage is not needed and the wound is closed after careful approximation of the deep fascia

ARTHRITIS OF THE WRIST

Acute Arthritis—This is nearly always a sequel to infection of the tendon sheaths or palmar spaces Generally the joint is the site of a reactionary effusion or a plastic synovitis which leads to ankylosis without suppuration In such cases the treatment is to immobilise the wrist in dorsiflexion and institute a full course of systemic penicillin therapy Less often suppurative arthritis develops the carpal bones are involved and there is severe toxaemia In such cases open drainage may have to be established This may be performed from the back through an incision to the radial side of the extensor indicis proprius or from the ulnar side

Chronic Arthritis.—The wrist joint may be affected as part of a widespread rheumatoid arthritis The treatment is usually on general lines though occasionally arthrodesis may be considered when the active phase has subsided leaving a small range of painful movement

Osteo-arthritis of the wrist and carpal joints is a not infrequent complication of ununited fracture of the scaphoid bone In such cases also arthrodesis has a definite place

Arthrodesis of the Wrist should be carried out without injury to the radio-ulnar joint to avoid loss of pronation-supination A dorsal incision is made between the extensor pollicis longus and the extensors carpi radialis laterally and the common extensor of the fingers medially The dorsal capsule is incised vertically over the whole extent of the carpus Attempts to excise the articular cartilages are not usually satisfactory and it is necessary to use a dorsal graft to ensure fusion

The graft is taken from the tibia or the ulna and laid in a bed prepared by cutting a gutter in the lower end of the radius the back of the carpus and the base of the third metacarpal. At each end the graft is well countersunk with the wrist in 15 dorsiflexion (Fig 119)

The joint is kept in this position by a plaster cast which is worn until the fusion is sound—generally in three to four months time



Fig 110

Arthrodesis of the wrist by means of a dorsal bone graft between the radius and the third metacarpal performed for arthritis following Kienbock s disease

AFFECTIONS OF THE RADIO-ULNAR JOINT

Ankylosis.—This gives rise to a disabling loss of pronation and supination It may be due to fracture of the radius involving the joint to subluxation of the joint in association with fracture of the lower third of the radius to osteomyelitis of the lower end of the radius or to rheumatoid arthritis

In the traumatic cases relief of pain and almost complete restoration of movement may be obtained by removal of the head of the ulna the line of section being situated an inch above the styloid process The wrist is immobilised for a few days and thereafter rotary movements are energetically practised

Madelung's Deformity —In this common deformity the lower end of the radius is displaced forwards relative to the ulna which therefore forms an unnatural and unsightly prominence on the dorsum of the wrist It sometimes occurs as a congenital deformity but of greater importance from the point of view of treatment are the acquired traumatic types which follow malunited fracture of the lower third of the radius and injuries which cause rupture or gradual stretching of the inferior radio-ulnar ligaments and capsule

In deformity due to fracture improvement in appearance results

from shaving off the subcutaneous prominence of the lower end of the ulna and correcting the alignment of the radius by osteotomy In the other traumatic types an attempt may be made to repair the torn ligaments or to replace them by a fascial strip which binds the two bones together In the very chronic variety resulting from gradual stretching of the ligaments—a type common in women and others whose work entails much wringing or rotary movement of the wrists—immobilisation in plaster is essential at the outset Thus is followed by physiotherapy and a leather wrist support or corset should be used for a prolonged period afterwards

KIENBOCK'S DISEASE

In this disease as a result of trauma the cancellous bone of the lunate undergoes absorption becomes soft and unresistant and may undergo compression deformity There is considerable limitation of movement especially of dorsiflexion and much pain Eventually osteo-arthritic changes supervene and the joint may be completely fixed.

The treatment in the early stage before deformity has occurred should take the form of prolonged immobilisation in a plaster cast from below the elbow to the metacarpal heads The wrist is placed in a position of 15° to 20 dorsiflexion if spasm of the muscles prevents this a short general anæsthetic should be given to cover the manipulation and the application of plaster

In the later stages after the bone has become misshapen, removal of the lunate is indicated unless arthritic changes have supervened In the latter event if pain persists after a period of immobilisation arthrodesis of the wrist should be considered (p 311 and Fig 119)

Removal of the lunate is effected through a dorsal incision between the long thumb extensor and the extensors of the carpus laterally and the common extensor of the fingers medially *After division of* the capsule strong palmar flexion and ulnar deviation bring the lunate into view and it can generally be recognised by the dorsal irregularity *and projection which are part of its deformity Removal is accom* plished by dividing the ligaments which anchor it to the scaphoid and triquetrum and by separating slips of the radio carpal ligament in *front by means of a periosteal elevator*

SPONTANEOUS RUPTURE OF THE EXTENSOR POLLICIS LONGUS TENDON

The tendon of the extensor pollicis longus occupies a narrow groove on the ulnar side of Lister s radial tubercle which acts as a pulley for it If the bony groove is irregular—as after posterior marginal or comminuted Colles fractures or in association with osteo-arthritis of the wrist—the tendon may be frayed by the repeated movements of the thumb until it finally becomes attenuated and breaks spontaneously or from *trivial violence A similar lesion* occurs in those whose duties involve continuous rapid play of the tendon in its groove—as in drummer boy s palsy

The rupture occurs within the sheath and opposite the radial tubercle The distal end of the tendon usually remains adherent to the bone so that it is easily found at operation. The proximal end retracts considerably but since it withdraws within its sheath its discovery and recognition are usually not difficult The lesion is a very disabling one for extension and abduction of the thumb are practically impossible

There is a choice of operative methods of repair As a rule it is impossible to suture the tendon after the frayed ends have been trimmed and the choice is between reconstituting the tendon by means of a free graft or transplanting the distal end into a neighbouring tendon

Both procedures give satisfactory results but in our experience those following free transplant are a little better and this method is to be preferred if a free graft can readily be obtained. The most convenient source is the palmaris longus fascia lata has also been used but if the palmaris is absent there need be no hesitation in implanting the distal end of the tendon into the extensor carpi radialis brevis In both methods the suture is effected with the thumb extended and after operation extension is maintained by a plaster splint for fourteen days After this active use is gradually permitted

TRAUMATIC TENOSYNOVITIS OF THE THUMB EXTENSORS

The tendon sheaths of the wrist are frequently the site of an acute aseptic tenosynovitis which may be initiated by injury or simply result from the rapidly repeated movements demanded by some forms of employment especially after a period of abstinence through leave or illness Any of the sheaths may be involved classically the thumb extensors but more commonly the flexor sheaths and in addition to swelling there is a typical fine crepitus on movement

The indication is to provide rest As a rule immobilisation for several weeks in a light plaster splint is sufficient to ensure relief The plaster should immobilise the thumb in the position of function '

DUPUYTREN'S CONTRACTURE

This is a progressive shortening of the palmar fascia especially on the ulnar side of the hand and treatment depends on the degree to which the deformity has proceeded. In the earliest phase a nodular thickening appears in the slip of fascia for the ring or little finger Further nodules develop and as the fascia gradually contracts the skin becomes puckered and tacked down, and the finger assumes a characteristic attitude of flexion at the metacarpo phalangeal and proximal interphalangeal joints The distal joint remains extended, because the digital slips of the palmar fascia extend only so far as the second phalanx Later the continued flexion at the joints leads to alteration in the shape of the articular surfaces in the metacarpo phalangeal joint a forward subluxation of the phalanx ultimately occurs

Treatment.—1 *Excision of the Nodule*.—In the earliest stages when there is simply a nodular thickening without actual shortening the

nodule should be excised under local anæsthesia Thereafter the patient is instructed to carry out repeated passive stretching of the finger

2 *Subcutaneous Fasciotomy*—When contraction has occurred and there is simple flexion deformity of the joints the shortened bands of fascia should be divided by a tenotome

Under local or general anæsthesia the skin is punctured alongside the shortened slip The tenotome should first be introduced horizontally and superficial to the fascia which is then carefully separated from the skin The blade is then rotated into the vertical position, and while the finger is kept extended the band of fascia is divided These manœuvres are repeated at as many points as are necessary In each case the surgeon must cut only against the resistance of the fascia in order to avoid inadvertent division of a flexor tendon or digital nerve

After the fasciotomy the puncture wounds are covered with a sterile dressing and the finger splinted in full correction The splint is retained for fourteen days After this period it can be discarded during the day but should be worn at night for several months

3 *Excision of the Palmar Fascia*—When the contraction has been long established and there is extreme flexion of the metacarpo-phalangeal joint and secondary articular changes a perfect result is not to be expected from simple fasciotomy Nevertheless a surgeon practised in the method will be able to effect a considerable improvement and may even rely on it in entirety The alternative in severe cases is excision of the contracted fascia but if joint changes or subluxation have occurred the correction will still be far from perfect

The initial incision should be placed in the distal palmar crease and if this access proves inadequate a longitudinal cut can be carried upwards from the first incision If the fascial bands in the fingers also require division separate digital incisions should be made either transversely at the proximal flexor crease or longitudinally on the lateral aspect of the finger The skin must be separated very carefully to avoid buttonholing and as the fascia is defined and excised the digital nerves and vessels should be sought and spared

The after treatment is similar to that following fasciotomy

4 *Plastic Operations and Amputation*—In cases with subluxation or marked flexion-contraction of the metacarpo-phalangeal joint resection of the metacarpal head may be considered and in extreme cases the palmar skin and fascia may both be excised and the raw area covered with a whole thickness skin graft In such cases however the end result is generally unsatisfactory and amputation of the finger is more commonly advised

WEBBED FINGERS (SYNDACTYLY)

The web joining the fingers may take the form of a thin bridge of skin only or a fleshy mass comprising a full thickness of subcutaneous tissue

In the first type simple incision of the web followed by suture gives excellent results In the second type the choice of treatment

is more difficult The usual method is to divide the joining tissues bv incisions designed to leave volar and dorsal flaps to cover as much of the fingers as possible and separate the fingers widely, the raw surfaces are then covered by Thiersch grafts on a mould of dental wax, or bv a free whole thickness graft particular attention being given to the reconstruction of an ample web

DERANGEMENTS OF THE EXTENSOR MECHANISM OF THE FINGER

Extension of the finger is effected by the extensor tendon or apo neurosis The tendon divides on the dorsum of the proximal phalanx into a middle slip which runs distally to be inserted into the middle phalanx and two lateral slips which fuse and become attached to the base of the distal phalanx Disinsertion of the terminal part leads to the common and disabling deformity of mallet finger while avulsion of the middle slip also gives rise to a characteristic disability A third derangement of the extensor mechanism results when there is an obstruction in the flexor tendon sheath which prevents the free sliding of the tendon as extension is carried out— trigger finger

Mallet Finger—The tendon slip may be avulsed alone or along with a flake of bone from the base of the distal phalanx. In children the entire epiphysis is sometimes detached The injury most often responsible is a blow on the tip of the finger—hence the synonym cricketer s or baseballer s finger

The deformity is very characteristic The distal interphalangeal joint is flexed by the unopposed pull of the long flexor tendon, and active extension is impossible but the joint can be extended passively

The behaviour of the avulsed tendon has an important bearing on treatment The retraction of the terminal slip is never great owing to its connection with the middle slip instead it reinforces the action of the middle slip and produces a gradual hyperextension at the proximal interphalangeal joint

In recent cases a good result is to be obtained from simple immobil isation The extensor tendon is re laxed by hyperextending the distal joint and flexing the proximal inter phalangeal joint so as to cause the middle slip and with it the attached terminal slip to be drawn distally The finger is then immobilised in plaster of Paris The patient is first shown how to maintain the required position by pressing the tip of the finger against the thumb A strip of cellona bandage is rolled in the form of a tube and guided on to the finger which is then dipped in water The finger and its covering plaster are then squeezed to express the excessive water and to mould the cast accurately to the digit The patient holds the finger in the position



Fig 190

Smillie s method of treating mallet finger dry plaster roll applied. (*Farquharson.*)

already demonstrated to him until the cast has set (Fig 121) The plaster is kept on for at least six weeks

In recent cases this procedure may be quite painful If so the injection of 2 to 3 c c of 2 per cent novocaine over the base of the terminal phalanx will facilitate the application

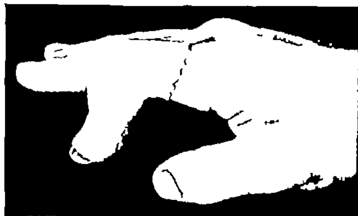


Fig 121
Smillie's method of treating mallet finger wet plaster moulded in correct position. (*Farquharson*)

In long standing cases the patient has generally succeeded in overcoming the effects of the disability to such an extent that treatment is unnecessary If correction is for any reason desirable the detached tendon may be secured by a removable wire suture

Avulsion of the Middle Slip of the Extensor Tendon—This injury leads to flexion at the proximal interphalangeal joint with gradual hyperextension of the terminal joint Sometimes when the proximal joint is flexed the lateral slips of the tendon slide so far to either side that active extension is impossible without assistance

In both varieties of the disability the amount of retraction of the proximal end is negligible and a perfect result usually follows immobilisation in plaster for a few weeks The proximal joint in this case should be kept fully extended If this fails the central slip may be sutured in position with a removable stainless steel wire stitch or the lateral slips may be stitched together over the back of the proximal interphalangeal joint

Stenosing Tendovaginitis at the Radial Styloid.—Localised fibrous thickening of the long abductor and the short extensor tendon sheaths of the thumb may lead to stenosis and to interference with the free movement of the tendons The lesion is situated immediately above the entrance of the tendons into the fibro-osseous tunnels between the superficial dorsal carpal ligament and the lower end of the radius

The swelling is usually a palpable firm nodule about ½ in above the radial styloid process and abduction and extension of the thumb are painful and difficult

In the pre-stenotic stage complete relief may be obtained by immobilisation of the wrist in plaster with the thumb extended and abducted

When stenosis is present or there is a palpable hard swelling operation should be urged Local anaesthesia should be used as it ensures the patient's co-operation he is able to say at once when the disability is relieved A short incision is made in the long axis of the tendons at the point affected The thickened parts of the sheath are divided with a fine bladed scalpel the cut extending into the

healthy sheath above and below, the sheath is left open and the wound closed

Trigger Finger—This is a variety of stenosing tendovaginitis The constriction in the sheath is situated at the level of the metacarpo phalangeal joint immediately above the expansion on the tendons at the point where the sublimis splits to allow the profundus to pass through. The strong flexor muscles are able to draw this expansion proximally through the constriction in flexion but the less powerful extensor muscles are unable to drag it back again Extension is therefore impossible unless assistance is given in which case the finger snaps into the straight position.

Treatment is simple and effective Under local anæsthesia the sheath is exposed through an incision in the line of the distal skin crease and the stenotic part of the sheath incised in the long axis of the tendon and on its lateral side

Snapping Thumb—This is in all respects similar to trigger finger The incision for exposing the sheath should be placed along the distal part of the base of the thenar eminence and the thenar muscles are drawn laterally to display the thickening in the sheath.

J B

WOUNDS OF THE HAND AND WRIST

Though a severe hand injury very seldom constitutes a threat to life its effect on the wage-earning capacity of the unfortunate victim especially if a manual worker may be disastrous Consequently such cases deserve to be regarded as acute surgical emergencies requiring the utmost care in diagnosis and treatment both immediately after the injury and possibly for many months afterwards until such time as the maximum possible function has been restored to the limb and the patient has been resettled in the most suitable form of employment available In order to achieve this continual supervision is required not only of the injured structures themselves but also of the rest of the limb and of the patient as a whole It is for example of little avail to restore continuity in divided tendons and nerves if during the treatment the joints of the affected limb are allowed to become stiff and frozen It is therefore highly desirable that all but the most *trivial* injuries of the hand should be treated in hospitals where adequate theatre and physiotherapeutic facilities are available and where a surgeon experienced in this type of work can himself supervise the treatment from beginning to end

EXAMINATION OF THE WOUNDED HAND

The nature of the injury and the site of the wounds will generally give some indication of the structures likely to have been damaged. Specific tests should always be carried out to ascertain the integrity or otherwise of the tendons and nerves likely to have been involved and the results of these tests even if negative should be carefully noted

The state of the circulation must be estimated for this often determ whether or not amputation of one or more digits will be necess X ray examination will often be required to determine the exter injuries to bones and joints

PRIMARY TREATMENT OF WOUNDS

In most cases immediate surgical treatment of wounds wil necessary and except in the case of small wounds of the skin complicated by damage to deeper structures this is best carried in a well-equipped theatre with good anæsthesia and hæmostasis

Anæsthesia.—General anæsthesia is to be preferred as with it re good hæmostasis can be secured and the surgeon can be more delibe and painstaking in his treatment of the wound *Nerve block anæsth* is sometimes more convenient and can be quite satisfactory when wound is confined to the distal half of a digit The tissues at the l of the digit are infiltrated with 2 per cent procaine without adrenal the initial injection being made on the dorsal aspect where the i is less sensitive but care being taken that an adequate amount of solution is deposited in the region of the two proper digital ner which lie in the subcutaneous tissue on the antero-lateral aspect the digit A rubber catheter tightly bound round the base of digit can be used to secure hæmostasis

Hæmostasis.—Except when skin grafting operations are being p formed a pneumatic tourniquet should be used in nearly all ha operations When its use is preceded by the application of an Esma rubber bandage almost complete exsanguination of the part can achieved and any operative procedure is rendered comparatively simp When properly applied this form of hæmostasis is quite safe and tourniquet can be left continuously in position for as long as two a a half hours without fear of causing a tourniquet palsy The meth is as follows

Any wounds are covered with sterile gauze and the limb is wrapp in a sterile towel The Esmarch bandage is then firmly applied fr the fingers up to above the elbow so as to exsanguinate the parts is important that this bandage should be applied *smoothly* and gre care must be taken that no turn becomes folded into a narrow tig band for this may easily cause a compression lesion of one or more the main nerve trunks A pneumatic tourniquet or sphygmomanomet cuff is then applied to the arm above the upper end of the Esmar bandage and inflated to a pressure of 250 to 300 mm Hg which shou be maintained throughout the operation The Esmarch bandage removed before preparing the limb for operation

Incisions in the Hand and Fingers.—In all operations on the han skin incisions must be carefully planned so that the resulting scars w not be a source of disability As a general rule they should be mac to run in or closely parallel to the natural skin creases and incisior crossing these creases at right angles should be avoided The reaso for this is that the scars resulting from the latter type are constantl subjected to longitudinal stresses during movements of the part anc

in many individuals this gives rise to keloid changes in the scar which subsequently shortens and causes a flexion contracture

Bad Incisions.—From the foregoing it will be inferred that most longitudinal incisions on the palmar or dorsal surfaces of the hand and digits should be avoided Particularly bad is a longitudinal incision passing from the palm to the flexor aspect of a finger in its midline Incisions on the dorsal aspect of a digit near the base of the nail must be made with care for fear of causing damage to the matrix which will lead to unsightly ridging of the nail

Useful Incisions—In the palm of the hand when it is felt that an incision in one of the natural skin creases will give inadequate exposure or will overlie the site of possible tendon suture an L shaped incision as illustrated in Fig 122 will give excellent access to most of the structures and will be found to heal satisfactorily The proximal end of this incision can be continued up the forearm if required, an S shaped curve being made at the level of the wrist as indicated by the dotted line It may be thought that the horizontal part of the palmar incision would be liable to divide the digital nerves and vessels but actually these structures with the exception of the one mentioned below lie in loose areolar tissue well beneath the deep fascia and in the same plane as the long flexor tendons and they are in no danger provided the incision is made with reasonable care The incision is deepened through the white glistening fibres of the palmar fascia and the flap of skin and fascia thus outlined is reflected laterally in one piece

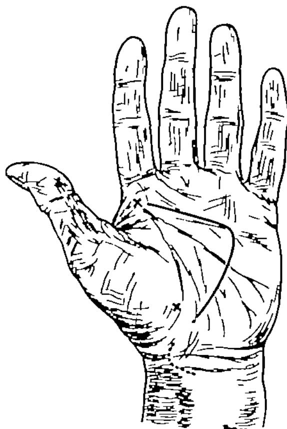


Fig 122

Standard incision for exposure of most of the structures in the central portion of the palm. The incision can be extended into the forearm if required (dotted line). X marks the two "danger areas" referred to in the text.

In making this or other incisions in the palm there are *two danger areas*—areas where damage to underlying structures may be inflicted unless great care is taken These danger areas are near either end of the standard L shaped incision Near its distal end just where the proximal and middle palmar skin creases unite *the digital nerve to the radial side of the index* lies immediately beneath the skin uncovered by any appreciable layer of palmar fascia It can easily be felt in the intact hand and can be rolled against the underlying head of the second metacarpal Near the proximal end of the L-shaped *incision the*

structure in danger is *the motor branch of the median nerve* though it lies a little to the radial side of the incision and is more liable to be damaged during reflection of the flap than by the actual skin incision The nerve after hooking round the distal border of the flexor retinaculum from its deep to its superficial aspect runs proximally (*sic*) and laterally superficial to the proximal portion of the flexor pollicis brevis before entering the thenar muscles to supply them In this part of its course the nerve is covered only by skin and a thin layer of the fascia covering the thenar muscles Furthermore it is often in the form of a thin transparent band not easily distinguishable from the thin fascia covering it Thus it will be realised that when working in this region the very greatest care must be exercised and the surgeon will not feel entirely at ease until the nerve has been identified In cases of difficulty or doubt the main trunk of the median nerve should be exposed beneath the distal border of the flexor retinaculum and the motor branch traced from its origin there

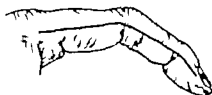


Fig 123
Standard incision for exposure of most of the structures in a digit

In the digits the most useful incision is a mid lateral one as indicated in Fig 123 From this it will be seen that the incision joins the posterior ends of the transverse skin creases on the flexor aspect Through this mid lateral incision which can be made on both sides of the digit if required adequate access can be gained to most of the structures either on the palmar or dorsal aspects The incision heals well and does not subsequently give rise to limitation of movement Incisions in the transverse skin creases on the flexor aspect are useful when only limited access is required to flexor tendons or digital nerves On the dorsal aspect midline incisions should be avoided as they tend to limit flexion Curved incisions are satisfactory and give good access to extensor tendons (Fig 124)

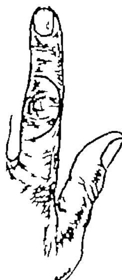


Fig 124
Type of incision used to expose part of the extensor apparatus

Suturing of Palmar Skin — When closing incisions or wounds in the palm a vertical mattress type of stitch is advisable to prevent inversion of the skin edges

Cleansing and Wound Excision —Cleansing of the skin in the neighbourhood of the wound is carried out in accordance with the principles already laid down (p 28) and the arm is draped with sterile towels on an arm rest or side table

At this stage a decision must be made whether to attempt to conserve damaged digits or to perform immediate amputation This is always an important and often a difficult decision The only absolute indication for amputation is non viability from destruction of blood

supply and in other cases many factors have to be taken into account such as the type of patient his occupation and even his economic circumstances In general a damaged finger which is likely to require many months treatment before reasonable function can be restored should be amputated and in assessing this the state of the skin blood vessels nerves tendons bones and joints must be noted. The state of the remaining digits is important for with multiple finger injuries the bias should be towards conservative treatment The thumb should always be preserved if at all possible or if amputation is essential the maximum length of stump should be retained It is seldom worth retaining an index finger stump proximal to the middle phalanx whereas in a manual worker a proximal phalanx with good flexion at the metacarpo-phalangeal joint can be useful in the case of the ulnar three fingers which are used mainly for gripping

After thorough wound excision has been carried out the identity and state of the damaged structures must be investigated the wound being extended by suitable incisions for this purpose When the full extent of the damage has been assessed it is necessary to decide how much reparative work should be carried out at this stage and how much should be left to be done as a secondary procedure after wound healing has been achieved It must be borne in mind that the main aims at the primary operation are to sterilise the wound by surgical excision to obtain primary skin closure and to promote early wound healing Nevertheless if the circumstances are such that wound sepsis is unlikely it is often permissible and even desirable to undertake primary suture of divided tendons and, occasionally of divided nerves Each case must be considered as an individual problem and the procedure adopted naturally varies according to the nature and extent of the injuries

Loss of Skin.—When the loss of skin is such that the wound cannot be closed by primary suture without undue tension some form of primary skin grafting will be required In the common traumatic amputation of the fingertip a *full-thickness free skin graft* taken from the front of the forearm and sutured over the defect is often very successful It is important that normal skin tension be retained in the graft and that no bare bone be exposed in the area to be grafted. If the phalanx is exposed and cannot be covered by pulp tissue a full thickness skin flap can be raised from the thenar eminence the opposite forearm or the pectoral region and sutured over the raw area as a direct flap graft Such *full-thickness direct flaps* can be used to cover more extensive areas of skin loss on fingers or hand. *Free split-skin grafts* though they take well are not suitable for areas subject to pressure such as the palmar aspect of the hand or fingers but they are useful to cover defects on the dorsal aspect Small areas of skin loss on the palmar aspect of the fingers especially if the flexor tendons are exposed, are best closed by making incisions on one or both sides of the finger and mobilising the intervening skin The resulting raw areas on the sides of the finger are then split-skin grafted In extensive degloving wounds on the hand the detached skin flaps unless badly damaged can often be cleaned de fatted and replaced more or less

as full thickness grafts but sometimes it is necessary to resort to burying the hand in the abdominal wall

Free skin grafts whether split-skin or whole-thickness, require to be kept in place by firm pressure dressings This is best achieved by using a crêpe bandage of suitable width but *the greatest care must be taken in applying such bandages* which can very easily cause sloughing of the underlying tissues or gangrene of an entire digit

Divided Tendons.—In the case of a comparatively clean wound in which with the help of chemotherapy, sepsis is unlikely, primary suture of divided tendons is usually indicated but with the following exceptions —

1 When both sublimis and profundus flexor tendons are divided, only the profundus should be sutured The remains of the sublimis tendons should be excised in the neighbourhood of the proposed suture so as to give more lebensraum to the profundus

2 It is doubtful whether it is worthwhile attempting to suture flexor tendons between the distal palmar skin crease and the distal transverse skin creases of the fingers *i.e* where the suture line will be within the digital fibrous flexor sheath In these cases a secondary free tendon grafting operation is nearly always required

When the tendon of flexor profundus only is divided at or distal to the middle of the middle phalanx the distal stump should be excised and the proximal stump drawn down and attached to the base of the distal phalanx

Technique of Suture —The best suture material is stainless steel or tantalum wire but fine silk is quite satisfactory Catgut should never be used owing to the foreign body reaction it produces It is an advantage if the suture is attached at both ends to an eyeless fine straight cutting needle The method of introducing the suture is illustrated in Fig 125

After-care —The part is splinted so as to prevent tension on the suture line for three weeks after operation In the case of the flexor tendons fixation of the wrist in almost full flexion by a dorsal plaster slab is generally sufficient the fingers being left free After three weeks active exercises of the fingers are begun and the wrist is allowed gradually to straighten under plaster control Intensive active exercises must be continued for some months before reasonable function can be expected to return

Divided Nerves.—Only in very clean incised wounds should primary nerve suture be considered and, even then unless the conditions are ideal and the best facilities for nerve suture available it is probably better to leave the formal nerve suture to be done at a secondary operation after wound healing has taken place and any sutured tendons have been mobilised (see also p 157) If the two ends of the divided nerve are seen they should, however be approximated by a single stitch to prevent retraction and facilitate secondary formal suture

Compound Fractures and Dislocations.—The presence of fractures or dislocations will often necessitate modification of the programme of treatment In the fingers they are often associated with damage to the tendons and may constitute a relative indication for amputation

If not they will require appropriate treatment by reduction and splintage (see p 260)

Immobilisation.—For the first few weeks after a severe hand injury it is generally desirable and sometimes essential to immobilise the part The position chosen is important and this will of course have due

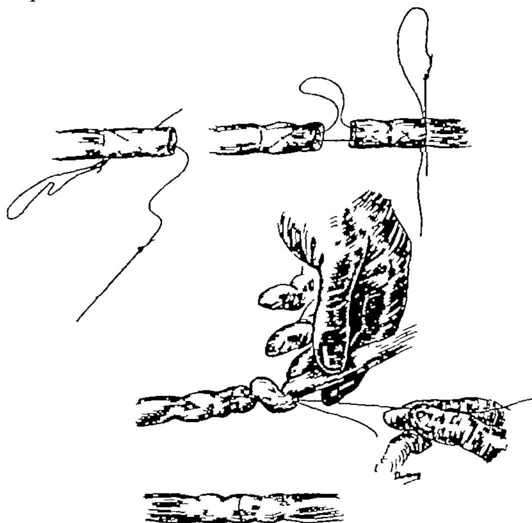


FIG 125

Method of uniting divided tendon (After Bunnell). After introducing the suture material, slack is taken up by sliding the tendon along first one and then the other free end before tying

regard for sutured tendons nerves etc but as a general rule the joints should be in the position of rest with the wrist slightly dorsiflexed and all the finger joints in slight flexion The first metacarpal should be placed in moderate opposition The metacarpo-phalangeal joints in particular are liable to become stiff if immobilised even *for a short* time in full extension Whenever possible uninjured digits should be left free and actively exercised from the start

Elevation.—After any severe injury or operation on the hand it is most important that the part be elevated to minimise the amount of œdema Prolonged œdema above all else gives rise to troublesome joint stiffness and must be prevented if possible The best method is

to have the patient lying flat in bed with the elbow supported by and the forearm and hand contained within a loop of 6 in wide bandage which is suspended from an overhead support as shown in Fig 126

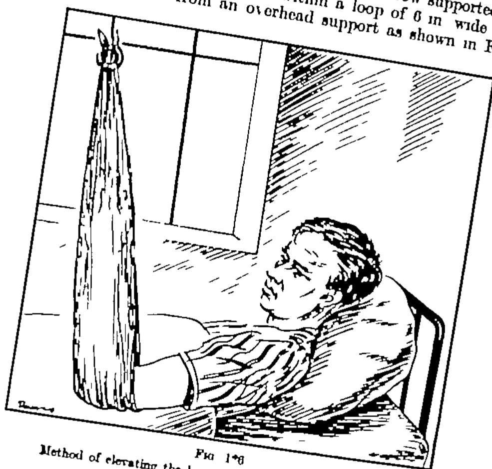


Fig 126
Method of elevating the hand to prevent or reduce oedema.

Should the patient require to be ambulant it may be advisable to fit him with an abduction splint to achieve the necessary degree of elevation of the hand.

Chemotherapy—After any potentially infected wound a prophylactic course of systemic penicillin should be administered

SECONDARY REPAIR OF TENDONS AND NERVES

In many cases of divided tendons and in most cases of divided nerves a secondary operation for the repair of these structures will be required The optimum time for such an operation is three to four weeks after injury provided wound healing is complete The mobilisation of joints and primarily sutured tendons may however necessitate further delay Should the wounds have been infected and only recently healed the secondary operation should be done under a penicillin umbrella

A R P

reduction can be obtained by manipulation under anæsthesia, but while acetabular growth may take place spontaneously in some cases in most operative reconstruction is required In children between five and eight years of age reduction is generally more difficult and may only be possible by open operation in this event reconstruction of the deficient acetabulum should be carried out simultaneously since the number of good results from a purely conservative régime is small. The operation on the hip joint may have to be supplemented by subtrochanteric osteotomy of the femur if anteversion of the neck is severe the distal fragment is then rotated laterally to ensure that the head of the femur engages the acetabulum in the normal posture of the joint In children over the age of eight or nine years deformity of the femoral head and neck is so gross that stable reduction cannot be hoped for and attempts at reduction and reconstruction are often followed by pain and stiffness as a result of the trauma to a joint already becoming arthritic Anterior transposition may place the head in a more stable position or osteotomy of the femoral shaft may correct the alignment of the limb and diminish lordosis and improve the gait In untreated and in relapsed cases symptoms arise sooner or later either in the form of severe backache from the mechanical disadvantage of the lumbar spine or as pain in the false acetabulum Improvement in the lumbar lordosis is most easily secured by bifurcation osteotomy of the femur but when the symptoms are referable to the false hip the possibility of relief from a vitallium cap arthroplasty must be considered especially in bilateral cases In adults the osteo-arthritis is best treated by arthrodesis of the hip (in unilateral cases) or by bifurcation osteotomy of the femur



FIG 127
Putti's splint for congenital dislocation of the hip. (*Farquharson.*)

In the first year of life *reduction* is obtained by gradual abduction of the hips combined with medial rotation. Elaborate manipulation is not required nor is anæsthesia Abduction is maintained by the use of Putti s splint (Fig 127) or some modification of it The splint is kept on day and night but is removed whenever necessary for cleansing and also daily to allow of gentle passive movements into extreme abduction and medial rotation The duration of treatment depends on radiological evidence of acetabular growth and splintage is generally required for eight to twelve months

Between the ages of one and five years reduction generally requires *manipulation under anæsthesia* The manipulation must be gently performed to avoid damage to the epiphyseal blood vessels otherwise avascular necrosis occurs and changes indistinguishable from Perthes disease supervene

Manipulative Reduction —Under full anæsthesia the hip and knee are flexed to a right angle and traction is applied in an upward and

medial direction while the pelvis is fixed by the surgeon's other hand. An attempt is thus made to lift the head of the femur into a position opposite the acetabulum and the hip is then swung into full abduction. Between the ages of three and five years the reduction may occasion some difficulty: this is probably due to contraction of the muscles because after traction for three to four weeks on a Thomas' knee splint a second manipulation is often successful.

The reduced hip is immobilised in a stable position by a plaster spica. The reduction is generally stable in a position of 45° of abduction and full medial rotation, and this position has the merit of forcing the head into the hollow of the acetabulum even when there is considerable anteversion of the neck. It is unnecessary to resort to the extreme 'frog' position of full abduction, right-angled flexion and lateral rotation. Immobilisation should be continued in the first instance for six months. If X-ray examination then shows evidence of acetabular growth immobilisation is continued for a further six months but in the absence of growth conservative treatment should be abandoned in favour of operative reconstruction of the acetabulum.

Reconstruction of Acetabulum.—Access is obtained by the *Smith-Petersen approach*. The incision begins at a point well back on the iliac crest and runs forward half an inch below the crest to the anterior superior spine and then downward in the interval between sartorius and tensor fasciæ latæ. The tensor is detached subperiosteally from the anterior superior spine and the incision deepened to the bone. Gluteus medius and minimus along with the tensor are then detached subperiosteally from the wing of the ilium and retracted laterally and backwards to expose the hip joint. The region of the false acetabulum is defined but it is unnecessary to open the capsule. A curved incision is made in the outer table of the ilium close to the postero-superior quadrant of the acetabulum and a 'shelf' of bone is levered outwards over the femoral head. The shelf should be just large enough to restore the acetabulum to a normal size and is held in position by chips or wedges cut from the ilium. The after-care consists of immobilisation in plaster till there is radiological evidence of healing. Thereafter four to six weeks of massage and exercises in bed precede a period of re-education in walking.

Between the ages of five and nine years reduction by manipulation is occasionally feasible but operative reduction is usually required. This is carried out through a Smith-Petersen approach and the acetabulum is reconstructed at the same operation.

After the age of eight or nine years reduction is usually contra-indicated because structural changes in the head and neck are so gross that a satisfactory result cannot be obtained. Anterior transposition is better: gradual traction is first applied to bring the head down to the level of the acetabulum and this is followed by hyperextension to bring the head forward in front of the acetabulum under the iliofemoral ligament and the iliotibial tract. In this position the head is more stable and the secondary curvature of the lumbar spine is diminished. Three to four months of immobilisation in plaster are required to establish the head in its new position.

In adult life pain due to stretching of the capsule and ligaments supporting the head or more rarely to arthritis in the false joint as well as lumbar backache may be considerably helped by femoral osteotomy There is little to choose between the Lorenz type of osteotomy and the ordinary subtrochanteric type provided that in *the latter the lower fragment* is hyperextended and abducted for then the lumbar lordosis is corrected and the upper end of the femur assumes a *horizontal position* with much less pressure on the deformed head when weight bearing is resumed In the Lorenz type of osteotomy the upper end of the shaft is placed in the old *acetabulum and abducted* to an angle of 30 to 40° so that the mechanical effects are very similar to those of the simple osteotomy (p 330)

COXA VARA

Coxa vara is a decrease in the angle between the neck and the shaft of the femur This angle is about 160 in the young child but normally diminishes to 130 or 125 in the adult Coxa vara is occasionally congenital more commonly it results from any disease which leads to disproportion between the strength of the femoral neck and the weight it is required to support The commonest causal diseases are pseudocoxalgia slipping of the upper femoral epiphysis and rickets These conditions have one notable feature in common—if untreated they lead to a severe grade of osteoarthritis in the young adult

Pseudocoxalgia (Perthes Disease)

In *pseudocoxalgia* there is avascular necrosis with consequent softening of the upper epiphysis and of the neck of the femur Under the stress of weight bearing the epiphysis becomes first flattened and later fragmented while the neck becomes more horizontal and thickened Revascularisation occurs eventually and the bone consolidates but the amount of deformity may be considerable and with the passage of time severe arthritis is inevitable

Treatment in the stage of *softening* can *minimise or prevent distortion* of the head and neck It is unfortunate that the symptoms at *this stage* are *often so mild* that the need for adequate treatment is not apparent Intermittent limp after exercise in a child between the ages of five and ten years should rouse suspicion of pseudocoxalgia and indicate the desirability of radiological examination The gross and characteristic changes seen radiologically are in startling contrast with the mildness of symptoms

Prolonged recumbency and traction are required to minimise the bony *distortion For the first three months* this is best obtained by the use of a Jones abduction frame and skin extension Thereafter *free movements* are permitted in bed but weight-bearing should not be resumed till there is radiological evidence of consolidation—generally *in six to nine months*

Slipping of the Upper Femoral Epiphysis (Adolescent Coxa Vara)

Slipping of the epiphysis occurs most commonly between the ages of ten and nineteen years The displacement is gradual The epiphysis slips backwards on the neck and to preserve the relationship between the head and the acetabulum the leg becomes laterally rotated through about 90 The epiphysis also tends to slip downwards on the femoral neck and this leads to a severe form of coxa vara and to early osteoarthritis The condition is often bilateral in which case the patient is of the fat boy type with Fröhlich s syndrome In unilateral cases the subject is of normal build and in good health

The diagnosis is suggested by a complaint of rheumatic ' pains in the hip (less often in the knee) associated with limitation of medial rotation without any flexion deformity At a fairly early stage a lateral X ray of the hip clearly shows the displacement and an anteroposterior view is suggestive because a flange of the epiphysis is no longer seen projecting above the upper border of the neck

The orthodox treatment is reduction by gradual traction but treatment by deliberate fusion of the epiphyseal line has recently been advocated Forcible manipulation and reduction by open operation should be avoided because they lead to avascular necrosis of the head whose blood supply is already precarious

Reduction by gradual traction is the method of choice in early cases The traction is carried out on a Jones frame using skin extension or skeletal traction through the tibial tuberosity In successful cases reduction takes place in two or three weeks but traction should be maintained for two months Thereafter massage and exercises may be carried out in bed but weight bearing is avoided until the neck of the femur has regained its normal radiological texture Both hips should thereafter be examined radiologically at regular intervals till the epiphysis fuses to make certain that displacement has not recurred. In severe irreducible cases light traction should be maintained till the risk of further displacement has passed When fusion of the epiphysis has finally taken place the coxa vara should be corrected by subtrochanteric osteotomy (see below)

Deliberate fusion of the epiphyseal line shortens the convalescence Arrest of growth is immaterial because the epiphysis fuses prematurely even without intervention. Fusion is most easily secured by inserting a Smith Petersen nail This should be introduced more backwards and more horizontally than for fractures of the femoral neck. It is desirable that displacement should be corrected before the nail is inserted but an excellent result can be obtained if the posterior displacement does not exceed *one-third* of the diameter of the epiphysis The after-care consists of rest in bed for a month and the use of crutches for a further two months The boy can then return to school but games should be *prohibited till* there is radiological evidence that the epiphyseal line is obliterated

Coxa Vara in Rickets

In the acute stage of rickets the softened femoral neck *is liable to* bend under the stress of weight bearing Consolidation of the bone must be hastened by general treatment which includes the provision of fresh milk and Vitamin D, and exposure to sunlight Deformity is prevented by confining the child to bed and by daily manipulating *the hips into full abduction*

When coxa vara has become established, treatment may be sought because of *the waddling gait limitation of abduction*, or aching pain in the hip At first there is no abnormality of the articulating surfaces and correction of the deformity by subtrochanteric osteotomy is effective (Fig 128) Severe arthritis however develops in early adult life and different treatment is then required (see below)



Fig. 128
Subtrochanteric osteotomy

Subtrochanteric Osteotomy—The femur is exposed immediately below the level of the lesser trochanter by a short lateral incision *which divides the iliotibial tract and vastus* lateralis The bone is divided through three-quarters of its diameter by an osteotome and the fracture completed by manipulation. The tendency of the fragments to override is prevented by traction for three to four weeks in a Jones frame and abduction is gradually increased to the required degree *A plaster* spica is then substituted for a further ten to twelve weeks *till there is radiological evidence of union.* A walking caliper should be worn for two months

OSTEOARTHRITIS OF THE HIP IN THE YOUNG ADULT

Osteoarthritis of the hip in the young adult differs in many important respects from the degenerative osteoarthritis of old age Here the *arthritis is often monoarticular and is the sequel to some gross structural* abnormality such as congenital dislocation of the hip or adolescent coxa vara and the *patient seeks not only relief from pain* but also economic rehabilitation The patient is usually healthy however and well able to undergo whatever type of major operation is considered most likely to give benefit

Several types of operation are available and the orthopædic surgeon *is largely guided by his own experience* Arthrodesis bifurcation osteotomy and arthroplasty are representative examples Arthrodesis *yields a stable painless hip* and is suitable when the range of movement is already limited Bifurcation osteotomy produces a painless hip and conserves a useful range of movement but does not restore movement when this is already lost Arthroplasty appears at first sight to be a rational procedure in all cases and the definition of sound operative principles and the introduction of *new operative methods* by Smith Petersen have led to a marked improvement in the results of this

rocedure It is especially indicated in cases of bilateral arthritis in which an attempt to restore movement in one hip is imperative but ven when unsuccessful it generally ffords considerable if not complete elief of pain.

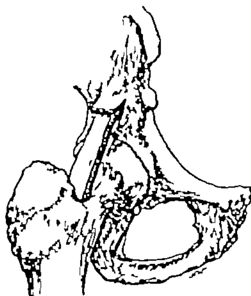


FIG. 129
Extra-articular arthrodesis of hip joint.

Arthrodesis of Hip—The usual modern technique aims at extra articular fusion by a bridge of bone between the acetabulum and the great trochanter (Fig 129) or between the femur and the ischium

In the ischio-femoral method a subtrochanteric osteotomy is carried out and a broad osteotome driven on into the ischium A massive tibial graft is then pushed through the divided bone ends into the ischium until it is firmly impacted its other end lies between the divided femoral ends This method has the advantage that any tendency to recurrence of adduction deformity which may dislodge an iliofemoral graft actually makes this fusion more secure

In the iliofemoral arthrodesis the incision begins an inch below and lateral to the anterior superior iliac spine and runs downwards and backwards over the great trochanter in the interval between tensor fasciæ latæ in front and gluteus medius behind These muscles are drawn apart to expose the upper part of the capsule and access is improved by detaching the gluteus tendon from the trochanter Gutters are then cut immediately above the acetabulum and in the trochanter to receive the ends of a free bone graft cut from the ilium or the tibia

Immobilisation in a full length plaster spica is maintained for three to four months till there is radiological evidence of fusion A short plaster spica is then substituted for a further two to three months and finally a leather hip corset may be used indefinitely

Combined intra-articular and extra-articular fusion is to be preferred when the head of the femur is not stable in the acetabulum for this may throw undue strain on the graft The anterior approach of Smith Petersen (p 327) gives satisfactory access All articular cartilage is erased, and the acetabulum and femoral head are adapted to each other before the extra-articular graft is inserted

Bifurcation Osteotomy (Lorenz)—The upper part of the femoral shaft is exposed through a short lateral incision which divides the iliotibial tract and vastus lateralis The femur is divided in a plane which passes upwards and medially to end generally above the lesser trochanter at the level of the lower border of the neck The division is carried out entirely with the osteotome to avoid the splintering which is apt to occur when the fracture is completed by manipulation

By moderately abducting the leg the upper end of the shaft is then displaced medially *until it lies immediately below the acetabulum* this is the most important part of the operation and the correct disposition of the bone should be verified by vision or if necessary by palpation After operation the limb is immobilised in a plaster spica till union occurs The upper fragment becomes adducted and unites with the shaft, which in *its new position takes most of the* body weight directly from the pelvis Union generally takes place in three to four months and no splint or retentive apparatus is required subsequently (Fig 130)

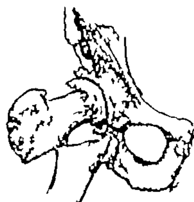


Fig 130
Bifurcation osteotomy (*Lorenz.*)

Arthroplasty —The anterior approach of Smith Petersen (p 327) is used to obtain a wide exposure of the front of the hip joint and the anterior part of the acetabulum The anterior capsule and a generous part of the acetabular margin are removed then the femoral head is reshaped by excision of the marginal osteophytes and the articular cartilage The acetabulum is deepened trimmed and reamed or filed until it is smooth and finally a vitallium cup is used to cover the femoral head The aim of the operation is to allow movement both between the femoral head and the cup and the cup and the acetabulum so that the selection of an appropriate cup is highly important The vitallium is non irritant and it has been shown that under it the femoral head may reacquire a covering of hyaline cartilage After operation traction is *maintained for a fortnight* to prevent redislocation Active movements in bed are then carried out for ten to twelve weeks and a walking caliper worn for six months The result is largely dependent on the patient who must persevere with active movement despite discomfort



Fig 131
Arthroplasty using vitallium cap.

More recently the restoration of movement by complete removal of the head and substitution of an acrylic resin protheses has given promising results. If early experiences are confirmed the scope of arthroplasty will be greatly enhanced.

DEGENERATIVE OSTEOARTHRITIS

In old age osteoarthritis is seldom restricted to the hip joint, and the patient is often feeble Treatment requires to be conservative rather than radical and the methods available are fully described on p 200 When simple conservative methods prove inadequate manipulation or immobilisation are often valuable and may give relief even for some years Bifurcation osteotomy (p 331) is useful in selected cases and arthroplasty may be considered when the general condition of the patient does not contraindicate a somewhat lengthy and major procedure

Manipulation may be carried out if the bony changes seen on X ray examination are not gross and if there is little or no muscular spasm It is particularly applicable when movement is restricted in one direction only Full anæsthesia is required and the joint is put gently through its full range of movement once in each direction Afterwards, a day or two is spent in bed, and massage and exercises are prescribed

Immobilisation is used when the bony changes and muscle spasm are marked Weight-bearing does not aggravate the pain and it is unnecessary to confine the patient to bed A short plaster spica extending from the pelvis to above the knee is satisfactory Full anæsthesia is needed to relax the spasm and tenotomy of the adductor tendons may be necessary to obtain a suitable position The spica is worn for three to six months and a leather hip corset is worn for a further six to twelve months

SUPPURATIVE ARTHRITIS

Suppurative arthritis is more common in children. The infection may be blood borne or it may be an extension from a focus in the neck of the femur The principles of treatment are fully described on p *191* and it suffices here to discuss details of technique

Relief of pain is best secured by skin traction on a Jones abduction frame or a Thomas bed knee splint The traction should be enough to immobilise the joint adequately and to ensure separation of the articular surfaces

Systemic penicillin therapy is begun as soon as the diagnosis is suspected 40 000 to 80 000 units are given three hourly by intramuscular injection

Aspiration of the joint is carried out as soon as possible the needle is inserted at a point 2 to 2½ in below the anterior superior iliac spine and pushed upwards and medially It enters the joint by passing under the lateral border of rectus femoris The cavity is evacuated as completely as possible and the contents sent for bacteriological examination including penicillin sensitivity Without waiting for the result 50 000 units of penicillin in 5 c c of saline are injected through the aspirating needle and left in the joint The aspiration may have to be repeated every two to three days

In young children with a bone focus in the femoral neck it is sometimes an advantage to ensure a constant high local concentration.

This is most simply achieved by inserting a sternal puncture needle into the neck of the femur from the great trochanter the penicillin solution is delivered at regular intervals or continuously through the needle and bathes the bone focus and percolates into the interior of the joint

If arthrotomy becomes necessary on account of extent or duration of the local lesion or lack of response to penicillin therapy the joint is best approached from the back The incision is carried laterally from the sacrococcygeal joint in the line of the gluteus maximus fibres The muscle fibres are separated and the interval between piriformis and obturator internus discovered The bulging capsule is easily displayed by retracting these muscles or by detaching the superior gemellus The capsule is left unsutured and a rubber drain is led down to the capsular opening

Immobilisation after arthrotomy is best secured by the use of a hip frame suitably altered to allow access to the wound Traction is maintained to prevent dislocation and when the upper part of the acetabulum is eroded traction must be prolonged In the more usual type of case traction can be discontinued when the purulent discharge diminishes The wound is covered with vaseline gauze and a plaster spica applied with the hip in 10° abduction 15 to 20 flexion and neutral as regards rotation Prolonged immobilisation is required to obtain sound ankylosis in this optimum position.

When the amount of destruction either of the femoral head or the acetabulum has been gross the hip may be left unstable Weight bearing will then lead to considerable upward displacement of the femur and it is then advisable to arthrodise the joint as soon as possible

J B

CHAPTER XIX

AFFECTIONS OF THE KNEE

THE surgery of the knee is concerned chiefly with the results of injury A single severe injury may damage the capsule accessory ligaments or semilunar cartilages while repeated minor injuries may lead to chronic arthritis Disorders of the extensor apparatus comprising the quadriceps the patella and the patellar tendon are somewhat less common but are important causes of disability Knock knee and bow leg resulting from rickets are less often seen now than formerly and suppurative arthritis is comparatively rare

INJURIES TO THE KNEE

The provision of rest for the joint and of exercises to maintain the tone of the quadriceps is an important part of the treatment of all types of injury

Rest for the joint is obtained by confining the patient to bed and by supporting the limb on a posterior splint A pad behind the knee serves to maintain a position 15° short of full extension. When the need for prolonged rest is evident it is more convenient to apply a plaster of Paris cast from the groin to the toes Immobilisation in full extension is generally to be avoided not only because it is un comfortable but because it throws undue strain on the posterior liga ments It must be emphasised however that the fully extended position is to be preferred when the injury is so gross that it is expected to result in ankylosis The reason for this is that bony union is seldom obtained and that even a strong fibrous ankylosis is liable to stretch with the strain of weight bearing in partial flexion

The maintenance of quadriceps tone is of fundamental importance Wasting especially of the vastus medialis occurs rapidly and gives rise to instability at the knee In addition the muscle fails to retract the synovial membrane from between the moving joint surfaces and repeated nipping gives rise to effusions or even hæmorrhages Neglect of the quadriceps is a contributory cause of disability in chronic arthritis and is a common cause of failure after operations on the knee

Quadriceps exercises should be begun at the earliest possible moment and should be carried out even when the knee is immobilised The patient is taught to contract the muscle actively by *attempting* to press the knee backwards against the splint and this exercise is carried out for five to ten minutes every hour Raising the leg with the knee straight is soon added and is later carried *out against* the resistance of a weight attached to the ankle

Acute Traumatic Synovitis (Sprain of the Knee Joint)

Twisting injuries may cause tears in the capsule and the synovial membrane of the knee joint An excess of synovial *fluid accumulates* the joint is the site of a dull ache and there is tenderness on palpation over the site of the tear The *effusion collects gradually and is obvious* only after some hours a point of distinction between simple synovitis and the more *serious hæmarthrosis*

The patient should be confined to bed for a few days If the *effusion is large the fluid is aspirated* the joint is then firmly bandaged over successive layers of wool Rest in a position of slight flexion is *maintained by a back splint* and quadriceps exercises are practised from the very start Weight bearing can generally be resumed within five to six days but the back splint is retained for two weeks and supervision continued until the joint is free from effusion and the quadriceps muscle is restored to normal

Acute Traumatic Hæmarthrosis

This results from severe twisting injuries and is often accompanied by damage to intra articular structures *e g* the tibial spine or the cruciate ligaments Distension of the joint with blood occurs rapidly *and is evident within an hour or so The swollen joint has a doughy* feel and there is often mild pyrexia on the following day as a result *of absorption of the blood*

The joint should be aspirated with full aseptic precautions (p 350) *If a definite lesion can be excluded by radiological and* clinical examination further treatment is on the same lines as for simple sprain but rest in bed should be continued for a fortnight and quadriceps exercises should be deferred for some days to avoid the risk of fresh hæmorrhage

Injuries to the Medial Collateral Ligament

Tears of the medial collateral ligament are common and may be caused by abduction or rotation strains Rotation injuries are usually less severe and damage is restricted to a few fibres at the attachment to the femur This is the injury commonly known as sprain ' of the collateral ligament In the major injuries which result from forcible abduction of the extended knee the ligament may be completely avulsed from the femur sometimes with a flake of bone or it may be torn across at a distal level most commonly opposite the joint Complete rupture gives rise to severe disability because the ligament plays an important part in maintaining stability of the knee

The extent of the damage is readily estimated on clinical examina tion In partial tears there is tenderness below the adductor tubercle and pain when the knee is abducted or rotated but lateral instability is absent and there is usually no effusion into the joint In com plete tears instability can be demonstrated by rocking the tibia laterally on the femur and there is considerable swelling which

may be due to a hæmarthrosis In tears at the joint level, it may be possible to palpate a gap on the inner side of the knee for the ligament is apt to become infolded and it may even be displaced between the articular surfaces of the joint

Treatment—In sprains it is generally sufficient to apply a small pad of felt over the site of the rupture and to support the joint by means of a crêpe or elastoplast bandage If pain is a prominent feature the injection of a few c c of 2 per cent procaine into the tender area or a thorough freezing of the skin over the site of the lesion with an ethyl chloride spray may usefully precede the application of the pad and bandage The patient need not lie up but the inner side of the sole and heel of the shoe should be raised by ¼ in in order to prevent valgus strain and the patient is instructed in the routine of quadriceps drill As a rule recovery is complete in two weeks

In complete ruptures at the upper attachment of the ligament the knee should be immobilised in a plaster of Paris cast after aspiration (if required) and a few days rest in bed. Quadriceps drill is practised from the beginning Splintage is discarded at the end of two months provided there is no tenderness at the site of the tear It is again advisable to raise the inner side of the sole and heel of the shoe by ¼ in

The presence of a distinct hollow in the line of the ligament and a suspicion that the ligament is folded or rolled up are indications for operative exposure and repair This should be attempted as soon as possible in order to avoid retraction, and to secure healthy fragments for suture

Untreated complete tears of the medial collateral ligament give rise to pain and instability especially in walking over rough ground The loss of the check action of the ligament renders the knee liable to repeated abduction and twisting strains but it must be emphasised that the chief cause of disability is the loss of muscular control due to atrophy of the quadriceps Restoration of quadriceps tone by exercises carried out under supervision is generally the only treatment required Occasionally when disability persists even after several months of such treatment it may be necessary to consider operative reconstruction of the ligament The usual method is to employ the tendon of semi tendinosus which is detached from its muscle belly but left with its tibial insertion intact It is embedded deeply under tension in a groove in the medial condyle of the femur and finally sutured to the remains of the original ligament The joint is immobilised in plaster for six weeks but regular quadriceps exercises are insisted upon throughout convalescence and active exercises are added when the plaster is discarded

Traumatic paracondylar ossification sometimes known as Pelligrini Stieda s disease is an occasional sequel of partial tears of the collateral ligament at the femoral condyle A discrete nodule of bone develops and there is a swelling which is tender on palpation The knee is painful sometimes markedly so and there may be limitation of flexion in its last degrees

Vigorous restorative measures must be avoided when para condylar ossification supervenes as in other situations when post-traumatic ossifications develop massage, manipulations and forced movements in the early stages may increase the size of the bony deposit Active movements within the painless range supplemented by the application of local heat or mild counter irritation, are the measures usually to be recommended then Later when the final disability if any can be assessed and there is no chance of the trauma of operation precipitating further bone production the residual nodule can be removed

Injuries of the Fibular Collateral Ligament

Tears of this ligament are uncommon because adduction violence is rare In most cases damage is limited to a few fibres at the insertion of the ligament into the styloid process of the fibula Less commonly the avulsion is complete and the tibia can then be rocked medially on the femur, in this event there may be an associated traction injury of the lateral popliteal nerve

Treatment is on the same lines as for injuries of the medial ligament Residual disability is slight even with unhealed complete rupture because the iliotibial tract and biceps tendon maintain stability Reconstructive operations are not required

Injuries to the Cruciate Ligaments

The *anterior cruciate ligament* extends backwards and outwards from the tibial spine to the lateral margin of the intercondylar groove of the femur It helps to prevent hyperextension and to limit the forward gliding of the tibia on the femur Rupture may be caused by forcible hyperextension or abduction it is also part of the extensive ligamentous damage associated with dislocation of the joint

The *posterior cruciate ligament* passes from the posterior intercondyloid notch of the tibia forwards and medially to the medial margin of the intercondylar groove of the femur It limits the backward gliding of the tibia on the femur but is taut in all positions of the joint Rupture of the posterior cruciate ligament alone is rare it is sometimes caused by forcible backward displacement of the tibia on the femur as by blows on the point of the tibial tuberosity

When the anterior cruciate ligament is ruptured the tibia can be drawn forwards on the femur even when the knee is extended ("drawer" sign) In posterior cruciate injuries the tibia can be pushed backwards on the femur a reverse "drawer" sign best elicited when the knee is flexed to a right angle

Cruciate injuries are common and serious In the early stages they are associated with hæmarthrosis and late unhealed ruptures are an important cause of persisting instability of the joint after trauma

Treatment.—With early and efficient treatment the function of the ligament may be restored especially when the lesion is isolated and not associated with gross injury to the other joint structures

Initially, the accompanying hæmarthrosis is aspirated and the joint supported on a back splint for 10 14 days The patient can then be allowed up, with the knee immobilised in a plaster cast from the ankle to the groin in a position just short of full extension Quadriceps exercises must be practised from the beginning and active exercises are required when the plaster is discarded at the end of three months

The treatment of unhealed injuries of the cruciate ligaments depends on the amount of disability present This varies from a feeling of insecurity to actual instability and is generally aggravated by coexistent injury to the medial collateral ligament and atrophy of the quadriceps Quadriceps exercises must be diligently practised and a firm crêpe bandage or elastic corset or knee cage may impart confidence Reconstructive operations have been devised but are for the most part unsatisfactory, and it is sometimes necessary to resort to formal arthrodesis of the joint

Injuries of the Semilunar Cartilages

Injuries of the semilunar cartilages are much the most common of the internal derangements of the knee joint They merit detailed consideration not only because they give rise to so much recurring disability but because they respond so favourably to treatment

The medial cartilage is the more frequently injured but it is now believed following improvements in diagnosis that the preponderance does not exceed the ratio of four to one Damage to it should always be suspected if the knee has been subjected to twisting strains during weight-bearing in the flexed position It must be pointed out that the classical feature of locking of the joint followed by synovial effusion is encountered only in comparatively gross displacements of the anterior part of the cartilage It does not occur with an isolated tear of the posterior horn or with a small longitudinal split In such cases there may be only a feeling of insecurity or a tendency for the knee to give way accompanied by a small effusion and some wasting of quadriceps These features are not pathognomonic and it is particularly in such cases that McMurray's test is of value With one hand the examiner palpates the knee With the other he grasps the foot and rotates it medially and laterally as the knee is gradually straightened from the fully flexed position. As the femur rides over the site of the tear there is a palpable or audible click accompanied by discomfort or pain. Practice is required to distinguish the click of a torn cartilage from the various clicks found in normal knees Occasionally when movement of the knee is painful as a result of recent injury or when the patient fails to co-operate it may be necessary to repeat the test under anæsthesia

Treatment —Manipulative reduction is necessary when the cartilage is impacted and the knee joint locked This operation can sometimes be carried out without an anæsthetic if the patient is willing to co-operate For the medial cartilage the tibia is externally rotated and abducted on the femur and from the fully flexed position is forcibly carried into extension (Fig 132) Reduction is indicated by

the loss of elastic resistance to full extension For the lateral cartilage the manipulation is similar but the tibia is adducted After reduction the knee is firmly bandaged over several layers of wool and immobilised on a back splint for three to four weeks Quadriceps exercises are carried out from the start

Excision of the damaged cartilage is indicated if impaction has been overlooked at the time of the injury, if impaction recurs later

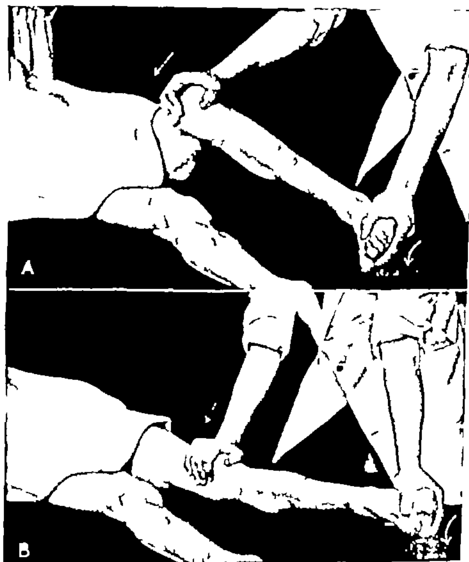


Fig 132

Manipulation for impacted semilunar cartilage. (*Farquharson.*)

or if there is persistent disability with slight effusion and quadriceps atrophy The operation is highly successful in the great majority of cases There is some evidence that this excellent functional result is partly due to growth from the synovial membrane of a ring of fibrous tissue which replaces the cartilage and resembles it closely in size and shape The few operative failures are due to neglect of the quadriceps to the use of too long an incision and to incomplete removal of the cartilage Quadriceps drill should therefore begin two

to three days before operation and be assiduously continued afterwards until the size of the muscle is completely restored

Removal of the Medial Semilunar Cartilage.—Strict asepsis is essential and the incision is usually made through a sterile muslin swab which covers the operative field The limb is rendered bloodless by means of a tourniquet and hung over the end of the operating table with the knee flexed to a right angle An oblique incision is made beginning close to the inferomedial margin of the patella and passing downwards and medially over the upper edge of the tibia (Fig 133) The capsule and the synovial membrane are divided in the same line Retractors are then inserted and the cartilage inspected The lesion may at once be obvious or at least demonstrable with the aid of a sharp hook but if this is not the case the operation is still proceeded with since the condition of the posterior horn cannot be determined by inspection from the front of the joint The anterior horn is first detached from the tibia and grasped in forceps By applying traction towards the interior of the joint the attachment of the cartilage to the capsule is clearly defined and readily divided to a point beyond the medial collateral ligament. It is then possible to secure a firmer grasp of the cartilage and to displace the whole structure into the intercondylar space The posterior horn is now divided to complete the removal. After operation the knee is liberally swathed in wool and a firm bandage applied before the tourniquet is removed On return to bed the limb may be supported on a back splint or rested between sand bags On the second day after operation quadriceps drill is resumed The patient may be allowed to get up and bear weight after the twelfth day provided there is no effusion

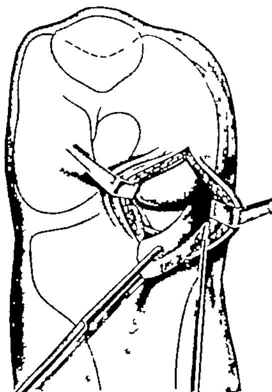


Fig 133
Excision of medial meniscus. (*Watson-Jones*)



Fig 134
Incisions for the removal of the menisci.

Removal of the lateral cartilage is essentially similar (Fig 134)

Post-operative complications are rare Infection is always due to a breach of aseptic technique Mild infection may be a cause of persistent effusion Severe infection requires to

be treated in the same way as any other suppurative arthritis (p 101) Hæmarthrosis may occur despite firm bandaging and if the quantity of blood is large the joint should be aspirated with full aseptic precautions.

Incomplete removal of a cartilage gives rise to disability only if the remaining fragment is loose Persistent effusion and the demonstration of a tag by McMurray s test indicate the need for further operation. The posterior horn of the medial cartilage is easily removed through an incision behind the collateral ligament with the knee flexed The incision can be carried down to the capsule without risk to other structures A similar incision can be used in the case of the lateral cartilage but the popliteus tendon must be carefully exposed and protected

Congenital Disc shaped Cartilage

In this uncommon condition the cartilage usually the lateral, is not only discoid but thick and a prominent ridge develops on its upper surface This ridge interrupts the smoothness of movement towards the completion of flexion and gives rise to a loud ' snapping ' noise The snapping is usually present from early childhood but is seldom accompanied by pain or discomfort unless the cartilage has been injured an event to which it seems predisposed Operation is unnecessary unless there is instability pain or evidence of superadded traumatic derangement

Cysts of the Semilunar Cartilages

Semilunar cysts are most commonly found in relation to the lateral cartilage and are due to cystic degeneration following trauma There are usually multiple foci in the body of the cartilage in addition to the main cyst which develops peripherally in the neighbourhood of the collateral ligament There is an obvious swelling on the lateral aspect of the joint which becomes tense and tender on full extension of the knee An aching pain is present in the joint and is aggravated by exercise

A cystic cartilage should be excised It appears to be sufficient to remove the cartilage alone through the usual small incision in front The main cyst is ruptured in the process and there is no recurrence if the excision of the cartilage has been complete

LOOSE BODY IN THE KNEE JOINT

The knee is the commonest site of loose body formation and the possibility of a loose body must always be considered in cases of internal derangement with locking The patient usually appreciates that there is something in the joint and the body may be palpable from time to time If the body remains partly attached to the synovial membrane locking may be absent and there may only be pain and a tendency for the knee to give way on performing certain movements accompanied

by recurrent effusion and quadriceps atrophy Radiological examination is diagnostic and must never be omitted in the investigation of internal derangements

A loose body which is giving rise to symptoms should generally be removed, but treatment must be modified in accordance with the pathological process responsible

In *osteochondritis dissecans* the loose body is generally single and should be removed. If it is still partly attached it should be separated from the femoral condyle and the edges of the gap should be made smooth In very early cases where separation has not begun healing can be achieved by prolonged immobilisation in a walking plaster cast A satisfactory result however can be achieved more quickly by exposing and excising the diseased area which is easily recognised by its dull yellow colour and by its give on pressure

In *synovial osteochondromatosis* the bodies are often multiple and many are partially or wholly attached to the synovial membrane If this is so it is generally better to carry out a formal synovectomy than to attempt to remove them individually

In *osteoarthritis* a loose body may be formed by detachment of an osteophyte Osteoarthritis is in general a contraindication to operations on the knee and the loose body should be removed only if it is giving rise to great disability through repeated locking of the joint The patient should be told that the operation is for the relief of the locking symptoms only and warned that the other effects of the disease will be unaltered

Technique of Removal of Loose Bodies.—The limb should be splinted and X ray examination carried out immediately before operation The splint is not removed till the patient is under anaesthesia and on the operation table In this way the exact situation of the loose body is determined and the most direct route of access can be selected.

An incision lateral to the patella is suitable for loose bodies in the anterior compartment of the joint

A posterior approach is used for loose bodies lying centrally in the posterior compartment The incision is made slightly medial to the midline of the popliteal fossa The popliteal vessels and the tibial nerve are retracted laterally care being taken to preserve the branches to the medial head of gastrocnemius

The parapatellar approach of Timbrell Fisher is selected when wide exposure is required It is particularly suitable when dealing with the multiple loose bodies of synovial chondromatosis A curved incision begins a hand s breadth above the patella and skirts its medial margin to end at the tibial tuberosity The skin flaps are reflected The fibrous expansion over the patella is divided in the midline and the medial flap is reflected to expose the capsule The capsule is split ½ in. from and parallel to the patella and the incision is carried upwards into the lower fibres of the quadriceps tendon and downwards alongside the patellar ligament When the synovial membrane is divided the patella can be displaced laterally by flexing the knee Exposure of the interior of the joint can be completed by dividing the infrapatellar pad and the synovial fold

LESIONS OF THE EXTENSOR APPARATUS

The extensor apparatus of the knee comprises the quadriceps muscle and its tendons the patella and the patellar ligament Rupture of any part of the apparatus is a serious injury It is most commonly due to violent contraction of the muscle against the resistance of the flexed knee as in trying to avoid a fall after stumbling Less commonly it may result from forcible manipulation of the knee when flexion is limited by post-traumatic shortening

The most frequent accident is fracture of the patella along with rupture of the quadriceps expansion over the front and sides of the patella Repair of the quadriceps aponeurosis is the essential part of treatment and this is facilitated by excision of the patella With advancing years simple rupture of the quadriceps tendon or rupture of the patellar ligament is more frequently encountered

Rupture of Rectus Femoris.—The rectus femoris may be avulsed from its tendon. The injury is often the result of a miskick at football, occasionally the result of a blow on the front of the thigh Retraction of the muscle belly gives rise to a highly characteristic bulge at the middle of the thigh with an obvious gap immediately below

Operative repair is difficult and unsatisfactory but an excellent functional result is obtained by immobilising the limb on a long back splint for six weeks The gap is repaired by strong fibrous tissue and the midthigh swelling which persists gives rise to no inconvenience

Rupture of the Quadriceps Tendon.—The rupture is situated close to the upper border of the patella and the gap is usually palpable The tear is often small and the injury may not be recognised

The ideal treatment is suture followed by three to four weeks rest in the extended position Conservative treatment however by im mobilisation in extension for eight to twelve weeks gives an excellent functional result for the gap becomes filled by strong fibrous tissue

Contracture and Fixation of the Quadriceps.—This is one of the most troublesome complications of fractures at the lower end of the femur particularly when skeletal traction through the femoral condyles has been employed. Less commonly it is a sequel to operations on the femur The muscle is usually fibrosed and bound down to the front of the femur Movement of the joint is not abolished but is limited to a few degrees of flexion by a characteristic unyielding obstruction. In many cases the patella is also ankylosed to the front of the femur

Preventive treatment while the fracture is immobilised includes quadriceps drill and passive movements of the patella from side to side Skeletal traction through the femur should be avoided if traction is necessary it should be obtained by a pin through the crest of the tibia immediately below the tuberosity

Curative treatment begins with a course of vigorous physiotherapy to restore the function of the knee When it becomes apparent that further improvement is no longer to be expected, manipulation may be required in a few cases if the disability is still great Manipulation must be carried out carefully and gently for there is considerable risk

of fracturing the patella or of rupturing the patellar ligament or quadriceps tendon. The surgeon should be content with only a small range of extra movement When this has been made good by exercise and massage further manipulation can be carried out Operative measures are not notably successful Mobilisation of the quadriceps through a long lateral incision and lengthening of the tendon of rectus femoris by the Z method are occasionally attempted

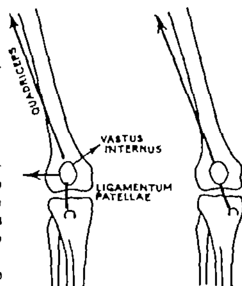


Fig 135
Habitual dislocation of patella. Lateral displacement when the quadriceps contracts is normally prevented by the medial pull of the vastus internus. (Watson-Jones.)

Rupture of the Patellar Ligament.—The rupture is situated close to the lower border of the patella and the upward displacement of the bone is evident It is generally possible to recognise the gap by palpation.

In early cases suture should be carried out followed by immobilisation in a plaster cast for six weeks It is usually possible to carry out a sound repair because a fringe of the ligament remains attached to the lower border of the patella

Habitual Dislocation of the Patella.—In recurrent or habitual dislocation the patella is displaced over the lateral condyle of the femur when the knee is flexed and the joint in consequence becomes locked. At first the attacks are followed by temporary synovitis but later there is no joint reaction. The lesion is disabling and if untreated predisposes to osteo-arthritis.



Fig. 136
Transplantation of the tibial tuberosity for recurrent dislocation of the patella.

In the normal knee the tendency to lateral dislocation of the patella is prevented by the tension of the medial part of the capsule and by the prominent lateral lip of the patellar groove Habitual dislocation is facilitated when the lateral lip is congenitally small, when as a result of rickets the medial condyle is disproportionately large and there is genu valgum and when as a result of traumatic dislocation the medial part of the capsule is torn.

The nature of the operation to be carried out depends upon the conditions present If there is marked genu valgum the deformity should be somewhat overcorrected by femoral osteotomy and at the same time the lower fragment should be slightly rotated medially in order to advance the lateral condyle In other cases the most generally useful procedure is to detach the tibial tuberosity with the insertion of the patellar ligament and to transplant it to a site far back on the medial surface of the tibia (Fig 136) This

operation may require to be *supplemented* Thus the contracted lateral part of the capsule may require to be divided or the lax *medial part plicated* or *if there is marked hypoplasia* of the lateral condyle the lip of the patellar groove may require to be elevated with an osteotome and held forward by insertion of a bone graft After any of these procedures the leg should be immobilised *for* six to eight weeks in a plaster cast This is followed by intensive physiotherapy designed *especially to restore the tone of vastus medialis*



Fig 137
Flexion deformity in advanced rheumatoid arthritis.

Epiphysitis of the Tibial Tuberosity (Osgood Schlatter's Disease) —The patient complains of aching over the tuberosity but this may be so slight that treatment is unnecessary If aching is troublesome the *knee should be immobilised* in plaster to avoid repeated traction on the tuberosity by the quadriceps Immobilisation is seldom required for longer than two months

CHRONIC ARTHRITIS OF THE KNEE

The principles *governing* the treatment of arthritis are fully described on p *194*, *and it suffices here to de*scribe the treatment of flexion deformity and the technique of synovectomy arthrodesis and arthroplasty

Flexion Deformity —This commonly results from *tuberculous or rheumatoid* arthritis (Fig 137) and less often from other diseases of the joint and anterior poliomyelitis There is a tendency to backward subluxation of the head of the tibia

When subluxation is absent the joint can usually be straightened by wedged plasters or simply by prolonged traction When subluxation is present traction is essential and it is necessary to add forward traction by a band passed round the upper third of the tibia In the wedged plaster method a plaster cast is applied with the knee in the deformed position When the plaster has set it is cut across behind the knee and an adjustable spreader is inserted. By this means the knee can be *gradually extended day by day* When extension is complete a fresh

cast is applied and prolonged immobilisation is then usually carried out with the object of securing ankylosis in the optimum position

The operation of capsulotomy may be required in extreme cases when contracture of the capsule and accessory ligaments prevents



FIG 138

The condition has been treated by arthrodesis of the knee using bone grafts after the method of Brittain.

correction by conservative methods The operation comprises sub periosteal elevation of the heads of gastrocnemius and of the posterior part of the capsule from the femur It may require to be supplemented by lengthening of the tendons of biceps semimembranosus, and semi tendinosus

Arthrodesis.—*Ankylosis of the knee in full extension* gives a stable

and painless limb If the joint has been allowed to ankylose in partial flexion the position should be corrected at operation and a formal arthrodesis carried out

The incision is U-shaped crossing below the patella and extending well up into the thigh on each side. The capsule and the ligamentum patellæ are divided in the line of the incision, and a flap containing the patella is reflected upwards The suprapatellar pouch of synovial membrane is removed along with the retropatellar pad of fat The cruciate ligaments are cut the semilunar cartilages removed and as much as possible of the synovial membrane at the back of the joint dissected away The articular cartilage of the femur and tibia is next removed and the plane of resection should correspond with the shape of the surfaces Similarly the articular cartilage of the patella is removed and a raw area made on the femur to receive it The raw surfaces are finally approximated with the knee in a position of extension, and may be fixed by a pair of excision pins or tibial bone grafts which pass obliquely from one tibial condyle to the opposite femoral condyle Metal pins soon become loose and at the end of two weeks can be pulled out The leg is immobilised in plaster for six to eight weeks A walking caliper is then substituted so that bone formation may be stimulated by weight-bearing Fusion should be sound in three to four months (Fig 138)

Arthroplasty—Arthroplasty at the knee is an unsatisfactory procedure It is difficult to combine an adequate range of movement with stability Nevertheless in severe arthritis affecting both knees an imperfect arthoplasty of one knee may be preferable to ankylosis of both

The knee joint is opened by a midline incision. The tendon of rectus femoris is lengthened by the Z method and the patella is reflected downwards The articular surfaces of the tibia and femur are trimmed smooth and a sheet of fascia lata is interposed. Any success which attends the operation depends on the co-operation of the patient who must begin movements of the joint as soon as possible after operation and persevere despite pain or discomfort

GENU VALGUM AND GENU VARUM

These deformities result when a child with rickets is allowed to walk during the active stage of the disease In genu valgum or knock knee, the chief deformity is contributed by the femur and deficient growth of the lateral condyle accentuates the normal angle of 170° which the femur makes with the extended tibia In genu varum or bow leg the chief deformity is in the tibia, the normal bowing of the bone being accentuated

Treatment of Genu Valgum.—In the active stage of rickets weight-bearing must be prohibited and anti rachitic treatment including fresh milk, vitamin D and sunlight must be given. The knee joints should be manipulated into full adduction daily and a well padded lateral splint applied at night

When deformity persists beyond the active stage of rickets a knock knee brace should be used and persevered with till the deformity is corrected or till the failure of the method is apparent The brace consists of a metal splint which lies along the lateral side of the limb and the limb is firmly bandaged to it both by day and by night

In later cases when the bones have regained their rigidity correction is only possible by supracondylar osteotomy of the femur The usual approach is from the lateral side through the iliotibial tract and the vastus lateralis The bone is exposed and divided subperiosteally through four fifths of its diameter the remainder is broken through by sharply adducting the leg The deformity should be slightly over corrected and in order to prevent any tendency to dislocation of the



FIG. 139

Genu valgum in an adult for which osteotomy at the upper end of the tibia is indicated.



FIG. 140

Genu varum in an adult for which more than one osteotomy will be necessary

patella the lower femoral fragment should be slightly rotated medially to advance the lateral condyle The limb is immobilised in plaster for eight weeks until the fracture is united Thereafter a walking caliper should be worn for three months

In the adult correction of genu valgum by supracondylar osteotomy should be avoided because this alters the alignment of the joint after adaptive changes have developed. It is better to remove a small wedge from the upper end of the tibia (Fig 139) The base of the wedge is situated in the medial aspect of the tibia about 2 in below the knee joint It may occasionally be necessary to divide the fibula also to obtain full correction After operation plaster fixation is maintained for six to eight weeks As a rule no splint or other apparatus is required beyond this period

Treatment of Genu Varum.—While the bones are still soft this is similar to the treatment of genu valgum

At a later stage in children the deformity can be corre osteoclasis A closed fracture is produced at the site of greatest ture by means of a special clamp or over an orthopædic wedg deformity is corrected and the leg immobilised for six to eight

In older children and in adults, *osteoclasis is unsatisfactory a* operation is preferable A simple transverse osteotomy usually but it may be necessary to divide the bone at more than on or to remove a wedge of bone with its base on the lateral side (Fi The deformity is corrected and the lower fragment slightly laterally to correct the *inpointing of the toes* *Immobilisa* continued till there is clinical and radiological evidence of sound

ACUTE SUPPURATIVE ARTHRITIS

The knee is the commonest site of acute arthritis The pr governing treatment are fully described on p 101 and it suffic to describe details of technique

Rest and the relief of pain are best secured by traction Thomas knee splint and skin extension.

Aspiration of the knee joint is readily carried out by enter joint on one or other side of the ligamentum patellæ or by e *the suprapatellar pouch in the midline of the thigh*

If drainage by arthrotomy becomes necessary incisions first instance should be made about 1 in to each side of the and parallel to its margins Additional incisions are usually re later because of the many recesses of the synovial cavity The pc *compartments are laid open by cutting down on forceps passed* wards over the sides of the femoral condyles The suprapatellar is laid open through a midline incision which splits the qua tendon Drainage tubes are unnecessary and may be harmful is sufficient to pack open the skin incisions with vaseline *Following operation quadriceps* exercises are begun as soon as p and traction is continued till the purulent discharge ceases exercises are then begun unless the degree of cartilage destr precludes the possibility of obtaining a mobile joint *In this* prolonged immobilisation in a plaster cast is carried out wi object of securing ankylosis in the optimum position

BURSITIS AT THE KNEE

The prepatellar bursa is commonly the seat of chronic inflamr due to repeated trauma The patient generally seeks advice b of an acute exacerbation when the bursa becomes tensely dist and tender Suppurative bursitis occasionally arises as a seq sepsis of the foot or toes Rarely other bursæ round the kn chronically inflamed these are best treated by excision

Acute prepatellar bursitis generally subsides rapidly with r bed and the application of heat. Aspiration is seldom required

resolution is delayed or exacerbations frequent the bursa should be excised. A U-shaped incision with its convexity passing above the bursa gives ample access The bursa strips easily from the patella and patellar ligament but is densely adherent to the skin from which it requires to be carefully separated by sharp dissection Drainage of the incision by a strip of rubber dam should be provided for twenty four hours

Suppurative bursitis is treated on the same lines as any other abscess Through and through drainage is provided by lateral incisions

J B

CHAPTER XX

AFFECTIONS OF THE FOOT

CONGENITAL DEFORMITIES

TALIPES EQUINOVARUS—This is the common type of congenital club foot The deformity is one of plantar flexion and *inversion of the foot combined with* adduction of the forefoot and occasionally also internal rotation in the lower third of tibia The toes are pointed and the heel is drawn up and shortened The whole foot including the heel is inverted so that the plantar surface faces medially or is upturned Owing to adduction of the forefoot the medial border is concave On the lateral aspect of the foot the talus projects as a rounded protuberance

The treatment is designed to correct these deformities It is important that treatment should start shortly after birth and be maintained continuously for a long period for the tendency to contracture persists and any intermission in the course of treatment will lead to the development of a rigid deformity which is difficult to correct

The treatment in infancy is to manipulate the foot into good position and maintain the correction by adhesive strapping or such splints as Denis Browne s The first manipulation should be carried out a week or two after birth—as soon as the skin is sufficiently resistive to correct pressure Subsequent manipulation with reapplication of adhesive strapping should be performed at intervals of seven to fourteen days until the age of three months It is important that the manipulation *should be done by an expert and not entrusted to the mother who* can rarely be relied upon to exert sufficient force to be of real benefit

At the end of three months the limb should be fixed in the over corrected position in a plaster case which must include the flexed knee and the thigh and be sufficiently tight to exert proper fixation The plaster should be removed every few weeks and replaced until the child has voluntary control of the foot in eversion as is ascertained by stroking the sole and noting that the foot passes into dorsiflexion and slight eversion This stage is rarely reached before the age of six months

Subsequently splints should be applied at nights to maintain the correction When the child is ready for walking the sole of the shoe should be raised by $\frac{1}{8}$ in on the lateral side

The child must be kept under observation and seen periodically at gradually increasing intervals until adolescence If there is any tendency to relapse during this period it is necessary to correct the deformity and apply a plaster case once more

TECHNIQUE OF MANIPULATION AND FIXATION —Throughout manipulation an assistant must protect the knee from strain by keeping it flexed and firmly held

The deformities are corrected in the following order —

Adduction —In the case of a left foot the surgeon's thumbs are placed over the protuberant talus the fingers of the left hand grasp the toes and those of the right hand the heel The forefoot and hind

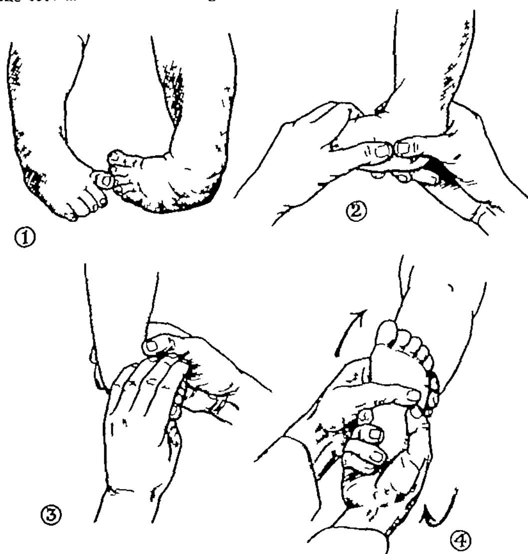


FIG 141
Manipulations for congenital club-foot.

foot are thus used as levers with the head of the *talus as a fulcrum* and leverage is exerted until the prominence of the talus is replaced by a hollow

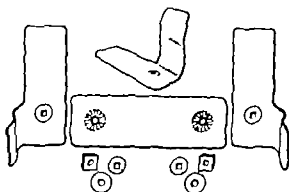
Inversion —The thumb of the right hand maintains its position but the left hand now encircles the forefoot and carries it outwards and upwards

Plantar Flexion —The right thumb is placed on the plantar aspect of the foot under the calcaneo-cuboid joint, the fingers still encircling the heel The left hand grasps the forefoot and by these grips the heel

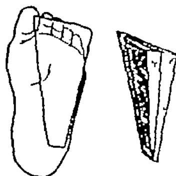
is pulled down and the forefoot dorsiflexed If the right thumb does not exert pressure over the calcaneo-cuboid joint there is danger of obtaining dorsiflexion at the mid tarsal joint with resultant boat shaped foot

Internal Rotation of Tibia—The left hand rotates the foot and ankle joint outwards whilst the right internally rotates the tibia below the knee

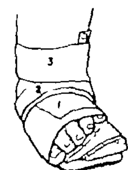
After correction the foot is easily controlled by adhesive strapping A strip of adhesive 1¼ in broad is attached to the medial side of the heel It is passed across the sole to the outer side of the foot and over



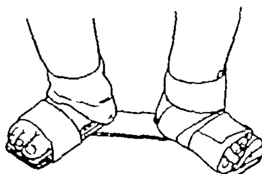
Components of Splint



Shaped and bevelled felts



Affected left foot strapped to foot-piece



Both feet fixed (The right foot is normal)

FIG 14
Application of the Denis Browne splint

the dorsum to the first metatarsal and thence across the sole again and up the outer side of the leg to the knee To hold the strapping in place transverse bands of adhesive are applied below the knee and above the ankle care being taken that they do not encircle the leg completely An absorbent bandage is now applied from the toes to the knee The nurse must be instructed to watch the circulation in the toes and to report at once if the vascularity is impaired If at any time the skin becomes tender the adhesive should be removed and a club foot shoe applied for a few days with wool and bandage only

Browne's Method—Denis Browne has advised an alternative method of treatment by using two metal foot-pieces which are attached to a transverse metal bar The foot pieces are L-shaped the vertical part

being applied to the lateral side of the foot and the transverse part to the sole

The feet are manipulated as previously described and fastened to the foot-pieces by adhesive strapping special care being taken to note that inversion of the forefoot is fully corrected Each foot piece is now fixed to the transverse bar by means of a lock nut which can be adjusted to permit of any degree of eversion In severe cases this may be as much as 90 The feet are manipulated repeatedly at intervals of fourteen days and the splint reapplied until voluntary eversion of the foot is gained. The muscular effort of kicking aids in active correction of the deformity Special toeless lacing boots are then substituted for the metal foot pieces and are retained as night splints The after treatment is as described above

Neglected and Late Untreated Cases —In such cases seen in late infancy the feet present a rigid deformity Manual correction over a padded triangular wedge should be carried out and the limb encased in plaster as described above

In childhood or later life the deformity is fixed by adaptation of the soft tissues and joints to the abnormal position In such cases it is necessary to divide the contracted soft tissues and perhaps to correct the bony deformity

Division of contracted plantar fascia is usually necessary The tight bands of tissue may be divided subcutaneously by means of a fine tenotomy knife inserted through a puncture wound the foot being manipulated into position as the various fibres are in turn put on the stretch and divided. An alternative method is to expose the plantar fascia near its attachment to the calcaneus by means of incisions on one or both sides of the foot and to separate the fascia along with the adjacent insertion of tibialis posterior from the bone Division of the tendo Achillis and of the posterior capsule of the ankle may also be required. After this type of operation the foot is manipulated into an overcorrected position and encased in plaster which is removed and renewed after four to six weeks Subsequently an inside iron should be fitted with an external T-strap to prevent recurrence of the deformity

In severe cases correction of the bony deformity is required. It is done either by taking a crescentic wedge from the anterolateral part of the tarsus or by Dunn's operation (p 356)

Congenital Talipes Calcaneovalgus.—In this deformity the reverse of equinovarus the heel is drawn down and the forefoot displaced upwards and everted It yields more readily to treatment which consists in fixing the foot in overcorrection for two months or so by means of adhesive strapping a padded metal splint or a plaster case When the child walks an insole should be given to raise the heel ⅛ to ¼ in.

PARALYTIC LESIONS OF FOOT

Most paralytic lesions of the foot follow anterior poliomyelitis Unless prevented by proper splintage the foot tends to undergo deformity as a result of contraction of the unopposed muscle groups

is pulled down and the forefoot dorsiflexed If the right thumb does not exert pressure over the calcaneo cuboid joint there is danger of obtaining dorsiflexion at the mid tarsal joint with resultant boat shaped foot

Internal Rotation of Tibia—The left hand rotates the foot and ankle joint outwards whilst the right internally rotates the tibia below the knee

After correction the foot is easily controlled by adhesive strapping A strip of adhesive 1¼ in broad is attached to the medial side of the heel It is passed across the sole to the outer side of the foot and over

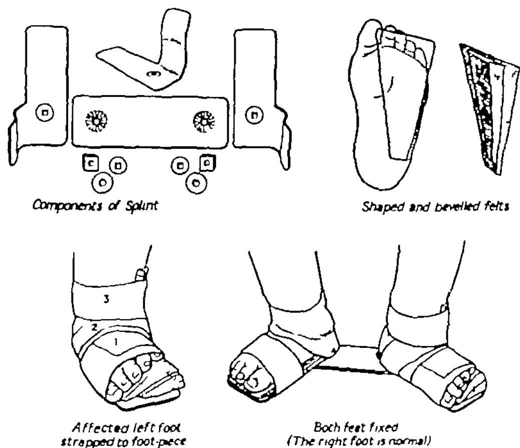


Fig 14*

Application of the Denis Browne splint

the dorsum to the first metatarsal and thence across the sole again and up the outer side of the leg to the knee To hold the strapping in place transverse bands of adhesive are applied below the knee and above the ankle care being taken that they do not encircle the leg completely *An absorbent bandage is now applied from the toes to the knee* The nurse must be instructed to watch the circulation in the toes and to report at once if the vascularity is impaired If at any time the skin becomes tender the adhesive should be removed and a club foot shoe applied for a few days with wool and bandage only

Browne s Method—Denis Browne has advised an alternative method of treatment by using two metal foot pieces which are attached to a transverse metal bar The foot pieces are L-shaped the vertical part

being applied to the lateral side of the foot and the transverse part to the sole

The feet are manipulated as previously described and fastened to the foot-pieces by adhesive strapping special care being taken to note that inversion of the forefoot is fully corrected Each foot piece is now fixed to the transverse bar by means of a lock nut which can be adjusted to permit of any degree of eversion. In severe cases this may be as much as 90 The feet are manipulated repeatedly at intervals of fourteen days and the splint reapplied until voluntary eversion of the foot is gained The muscular effort of kicking aids in active correction of the deformity Special toeless lacing boots are then substituted for the metal foot pieces and are retained as night splints The after treatment is as described above

Neglected and Late Untreated Cases —In such cases seen in late infancy the feet present a rigid deformity Manual correction over a padded triangular wedge should be carried out and the limb encased in plaster as described above

In childhood or later life the deformity is fixed by adaptation of the soft tissues and joints to the abnormal position In such cases it is necessary to divide the contracted soft tissues and perhaps to correct the bony deformity

Division of contracted plantar fascia is usually necessary The tight bands of tissue may be divided subcutaneously by means of a fine tenotomy knife inserted through a puncture wound, the foot being manipulated into position as the various fibres are in turn put on the stretch and divided An alternative method is to expose the plantar fascia near its attachment to the calcaneus by means of incisions on one or both sides of the foot and to separate the fascia along with the adjacent insertion of tibialis posterior from the bone Division of the tendo Achillis and of the posterior capsule of the ankle may also be required. After this type of operation the foot is manipulated into an overcorrected position and encased in plaster which is removed and renewed after four to six weeks Subsequently an inside iron should be fitted with an external T-strap to prevent recurrence of the deformity

In severe cases correction of the bony deformity is required It is done either by taking a crescentic wedge from the anterolateral part of the tarsus or by Dunn s operation (p 3o0)

Congenital Talipes Calcaneovalgus.—In this deformity the reverse of equinovarus the heel is drawn down and the forefoot displaced upwards and everted. It yields more readily to treatment which consists in fixing the foot in overcorrection for two months or so by means of adhesive strapping a padded metal splint or a plaster case When the child walks an insole should be given to raise the heel $\frac{1}{4}$ to $\frac{1}{2}$ in

PARALYTIC LESIONS OF FOOT

Most paralytic lesions of the foot follow anterior poliomyelitis Unless prevented by proper splintage the *foot tends* to undergo deformity as a result of contraction of the unopposed muscle groups

The foot usually assumes the equinus position less often the calcaneus varus or valgus positions or a combination of these according to the extent of the paralysis

The treatment varies Simple tenotomy and manipulation suffice in some cases in others tendon transplantation is occasionally of use to reinforce the weakened muscles When there is marked deformity a stabilising operation on bone is necessary The following are the procedures most commonly required



Fig 143 Subcutaneous tenotomy of the tendo Achillis.

Achilles Tenotomy—This operation is designed to lengthen the contracted Achilles tendon when there is an equinus deformity When considering this operation it must be remembered that if the limb is shortened a moderate degree of equinus deformity compensates for the shortening and should not be corrected

The tenotomy may be carried out by the subcutaneous or the open method In the subcutaneous method a ¼ in tenotome is inserted through a skin puncture immediately above the calcaneus and the lateral half of the tendon divided at this level The medial half is divided in the same way at a point 2 in higher When the foot is powerfully dorsiflexed the two halves of the tendon slide on each other and thus the required lengthening is gained without actual loss of continuity

In the open method the whole length of the tendon is exposed through a midline incision and divided by a long oblique incision After the foot has been dorsiflexed the overlap of tendon is sutured

In either method the foot should be fixed at a right angle in plaster for eight weeks

Tendon Transplantation.—This operation is occasionally used for varus deformity due to weakness of the peroneal muscles and unopposed contraction of the tibial muscles The insertion of the tibialis anterior is exposed the tendon is split longitudinally and the lateral half detached from the scaphoid The base of the fifth metatarsal bone is now exposed through a separate incision. The freed portion of the tendon is passed subcutaneously to this site threaded through a tunnel drilled in the bone and sutured under tension

For calcaneus deformity a similar operation may be performed the tendons of the tibialis posterior and long flexors of the toes and peroneal muscles being divided behind the ankle and fixed to the weak tendo Achillis and to the calcaneus

Stabilising Operations on Bone—*Naughton Dunn's Arthrodesis* is valuable in many paralytic deformities of the foot where simpler measures are inapplicable It is not usually performed until the age of fourteen, when ossification of the tarsal bones is well advanced The

subtaloid joint is opened up (its surfaces being erased) and a wedge of bone is removed from the middle of the tarsus including on the medial side the scaphoid bone and contiguous parts of the head of the talus and the cuneiforms and on the lateral side the contiguous parts of the calcaneus and cuboid bones The deformity can now be corrected the forefoot is shortened and the whole foot (except the talus) is displaced backwards at the subtaloid joint centralising it under the ankle for weight-bearing The subtaloid and mid tarsal joints become ankylosed and thereby stabilised while the useful movements of flexion and extension at the ankle are preserved

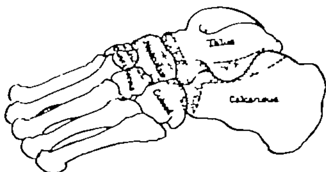


Fig 144

Dunn's arthrodesis. Shaded area indicates the portions of bone to be removed.

After operation the foot is encased in plaster Walking is allowed after four to six weeks the plaster should be renewed and maintained for at least six months

The Bone Block or Extra-articular Check Operation is designed to limit the movements of the ankle by introducing bony struts For equinus or drop-foot deformity a bone graft from the tibia is embedded in the upper posterior aspect of the calcaneus so as to impinge against the lower end of the tibia and prevent plantiflexion For calcaneus deformity a somewhat similar bone block may be constructed in front of the ankle joint Their sphere of usefulness is very limited

FLAT FOOT

The function of the foot is to bear weight and to propel the body forward in walking The dual purpose of support and active movement is dependent on muscle tonus and balance and any interference with these causes foot strain. The common type of flat foot—static flat-foot—may occur in adolescence during the period of rapid growth or in later life especially in obese subjects and in sedentary workers Malnutrition and debilitation through illness predispose to this condition.

Less commonly flat foot occurs as a congenital deformity as a sequel to anterior poliomyelitis or as a result of injury to the foot

The treatment of static flat-foot depends on the degree and duration of the condition and is conveniently described under the following headings —

1 Early or incipient flat foot
2 Intermediate or rigid flat foot
3 Late or bony flat foot
4 Spastic flat foot

Incipient Flat foot. — In cases of acute pain and swelling the symptoms are relieved most quickly by rest in bed with the feet elevated

on a pillow In less acute cases contrast baths relieve the aching sensation and are a useful measure to improve local circulation The feet are immersed in warm water for five minutes and then transferred to cold water for a few seconds This procedure is repeated for fifteen to twenty minutes Any tendency to recurrence of swelling is controlled by a supporting bandage extending from the toes to below the knee

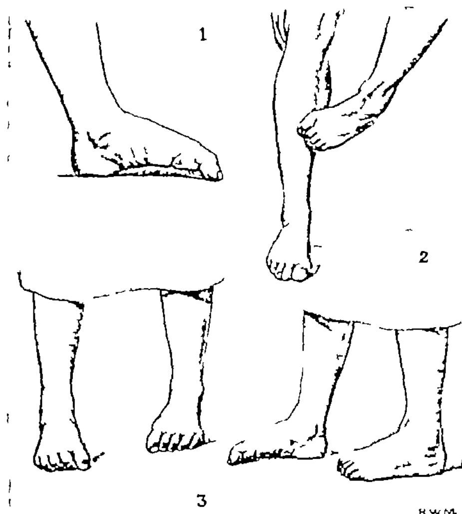


FIG 145
Exercises for flat-foot.
(1) and (2) Patient seated (3) Front and side view of walking exercise.

Adhesive material or an Unna's paste bandage is suitable for this purpose

Re-educational exercises are essential for permanent cure and as these *require the co-operation of the patient at* home as well as during attendance at clinic, it is desirable that they should be simple in nature and few in number

The following three are adequate —

(1) In the sitting posture with feet on the ground the toes are flexed and approximated to the heel thus accentuating *the longitudinal arch*

(2) With the foot arched as above the leg and foot are inverted below the knee and the great toe traces a line down the front of the opposite tibia from knee to ankle

(3) The patient walks with toes flexed and the feet inverted so that body weight is deviated on to outer border of the feet

These exercises bring the anterior and posterior tibial muscles into action and the patient is able to note the prominent tendon of the tibialis anterior as evidence of an exercise well performed

Such exercises as swimming and cycling are to be encouraged as these permit active muscle exercises without superincumbent body weight

The footwear should be of simple design with the inner border in a straight line the forepart roomy and the heel not more than 1 in high Benefit is gained in such a shoe by extending the heel forward on the inner side by ½ in and by raising it also on this side so as to deviate the body weight to the outer border Such raising varies from ⅛ in. in children to ¼ in. in adults This alteration is called Thomas heel or crook and elongation of heel Its action may be supplemented by raising the *outer* side of the sole by a similar amount

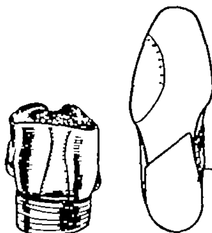


FIG 146

A right shoe with heel raised and extended on medial side and with sole raised on lateral side

Intermediate or Rigid Flat-foot.—In these cases attempts to correct the foot passively are resisted and cause great pain. Manipulation of the foot should be carried out under anæsthesia as follows (the description is for the right foot) —

(*a*) The patient lies supine and an assistant controls the knee in flexion The operator grasps the heel in his left hand with his thumb lateral and his elbow resting on the table The right hand encircles the dorsal aspect of the forefoot By this means the pillars of the longitudinal arch are approximated and the arch accentuated.

(*b*) The left hand now passes to the medial side of the heel and presses the lateral aspect of the foot against the operator's chest whilst the right hand inverts and supinates the forefoot

(*c*) The left hand still maintains inversion of the heel whilst the right hand pronates the forefoot

If the manipulation is effective in breaking down light adhesions and overcoming the deformity a supporting bandage should be applied Subsequently exercises are carried out as described above A crooked heel should be fitted and in some cases an outside iron with inside T-strap is useful.

Where simple manipulation fails further attempts may be carried out, using a padded triangular wedge of wood as a fulcrum If this

fails the deformity should be corrected by a Thomas wrench The foot is then encased in plaster the heel being inverted and the longitudinal arch well moulded The patient walks in the cast for four weeks or so Later a supporting bandage is applied and an iron and T strap are fitted

Late or Bony Flat-foot.—In such cases the joints of the foot have accommodated themselves to their new mechanical position Where pain is present it is usually due to secondary arthritic changes Treatment consists in fitting a moulded insole of felt and leather This is made from a plaster cast of the foot and is to be preferred to the various ready made supports which are supplied at random for all foot complaints In a few instances where pain is incapacitating Dunn s arthrodesis of the foot should be performed (p 350)

Spastic Flat foot.—A more accurate description of this condition would be valgoid foot with spasm or adaptive shortening of the peroneal tendons It may be secondary to trauma or to mild infective arthritis of the tarsal joints and occurs usually in young adults

The treatment should include general measures to eradicate any obvious septic focus which might be a source of infection and to improve the general health Local treatment consists in carrying out routine manipulation under general anaesthesia and tenotomising the tight peroneal tendons at the ankle joint where these are resistant In early cases novocaine injection of the peroneal nerve as it winds round the neck of the fibula by causing temporary paresis of the peronei allows the foot to be corrected In all cases fixation in plaster of Paris is maintained for at least two to three months. After treatment is similar to that of rigid flat foot

CLAW FOOT

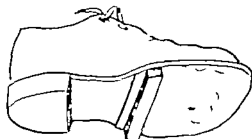
In this deformity the longitudinal arch of the foot is accentuated owing to contracture of the plantar fascia and other soft tissues of the sole The toes also are clawed In some cases the heel is drawn up and the tendo Achillis contracted Callosities are very apt to develop on the sole under the prominent heads of the metatarsal bones and are responsible for much of the pain characteristic of claw foot

The treatment depends upon the extent of the deformity In mild cases much benefit is gained by manual stretching and exercises with provision of suitable footwear In severe cases operation is required to divide the contracted soft tissues or to counteract their effects.

Mild Cases—Manual stretching should be carried out regularly by the patient With the knee fully flexed he grips the forefoot the fingers of both hands under the metatarsal heads the thumbs over the dorsal aspect of the toes Upward pressure is then exerted on the metatarsals and downward pressure on the toes in this way stretching simultaneously the contracted plantar structures the tendo Achillis and the toe extensors

Exercises have the same purpose The simplest is to flex the knees while standing with the forefoot on a 3 in bar

The footwear should be wide-fitting and low heeled in order to stretch the tendo Achillis In women accustomed to high heeled shoes it may be necessary to stretch the tendon forcibly before fitting low heels A metatarsal bar (¼ in broad and ⅛ in high) may be fixed obliquely behind the tread of the sole to stretch the plantar fascia and relieve pressure on the metatarsal heads Alternatively an insole fitted with a felt or sponge rubber bar ½ in high may be used


Fig 147
Metatarsal bar Note the correct position behind the metatarsal heads.

The callosities on the under aspect of the forefoot should be pared down with a corn razor and softened by applying 5 per cent salicylic acid in spirit

Severe Cases —In severe cases the plantar fascia and other contracted structures on the sole should be divided and the deformity overcome by wrenching A tenotome is introduced through puncture wounds on the medial side of the foot and passed laterally immediately deep to the skin of the sole The blade is then turned to cut against the plantar fascia and all tight bands are divided the forefoot being pressed upwards by the hand to render them prominent A Thomas wrench is then applied and the high arch is forcibly flattened

Occasionally it is necessary to divide the contracted tissues of the sole by open operation A 2 in incision is made on the medial aspect of the heel well forward and the plantar fascia and short muscles are separated by means of a periosteum elevator from their origin from the calcaneus The correction is then completed by wrenching

A well moulded plaster case is then applied Walking in the plaster is allowed. After two months or so a second manipulation may be advisable followed by further fixation in plaster

Tenotomy of the long flexors of the toes may be combined with the above procedure in order to correct the clawing of the toes The tenotomy is performed while the foot is held in overcorrected position by the Thomas wrench the tendons being divided subcutaneously near the proximal interphalangeal joints

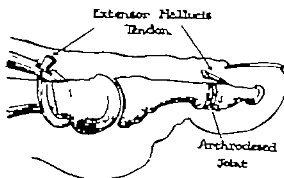


Fig 148
Tendon transplantation for claw foot.

Tendon transplantation is useful where there is a marked cock up of the great toe associated with dropping of the head of the first metatarsal. The extensor hallucis longus tendon is exposed through a dorsal incision over the metatarso-phalangeal joint and detached from its insertion into the base of the distal phalanx The neck of the first metatarsal bone is

then exposed subperiosteally, and a drill hole made obliquely downwards and medially through it The tendon is passed through this tunnel and sutured to itself under sufficient tension to elevate the metatarsal To prevent the formation of a hammer toe consequent on division of the extensor tendon the interphalangeal joint must be arthrodesed After treatment is as described above

Dunn's arthrodesis (p 356) may be required for severe long-standing cavus deformity with secondary arthritic changes

Disarticulation of the toes at the metatarso phalangeal joints is necessary when they are severely clawed especially when there are severe infected callosities

AFFECTIONS OF THE HEEL

The following are the common causes of pain in the region of the heel

Calcanean Apophysitis.—This is a form of osteochondritis affecting the posterior epiphysis of the calcaneus which is situated at the point of insertion of the tendo Achillis It occurs mainly in children from eight to fourteen years of age The treatment is to protect the part from pressure by fitting vertical strips of adhesive felt inside the shoe to either side of the heel A sponge-rubber insert may also be worn under the heel If these measures prove ineffective a plaster cast with walking stirrup may be applied for six to eight weeks

Calcanean Bursitis.—This condition is frequently seen in young women with poor peripheral circulation and is due to the pressure of ill fitting shoes Either the bursa deep to the tendo Achillis or an adventitious one superficial to it may be involved.

The treatment is to relieve pressure by boxing out the heel or by fixing vertical strips of adhesive felt inside the shoe to either side of the heel A soft leather or sponge rubber insert may also be worn under the heel.

If these measures fail operation is necessary A slightly curved vertical incision 3 in long is made lateral to the insertion of the tendo Achillis and the skin flap is elevated The superficial bursa if present, is excised and then with the foot plantiflexed to relax the tendon the deep bursa is sought and removed The posterior protuberance of the os calcis at its upper pole may be removed with a chisel or gouge to leave a hollow at this site The skin wound is then closed Following this operation an ordinary shoe can generally be worn after ten to fourteen days

Calcanean Spur —In this common condition there is a small pointed bony outgrowth on the under surface of the calcaneus Acute pain is caused by pressure over the spur In some cases there is also pain, indicative of periostitis on pressure upon the sides of the calcaneus.

The treatment is to fit a thick sponge-rubber insole under the heel. The insole should be hollowed out to relieve weight bearing at the site of the spur In acute cases with much periostitis a plaster case with walking stirrup may be used for six to eight weeks.

Where localised tenderness persists, the spur should be removed. A short incision is made along either the medial or lateral side of the heel and deepened to the bone The spur is located by palpation defined by incising and elevating the plantar fascia related to it and

removed with a gouge Walking is allowed after fourteen days a sponge rubber insole being worn for two to three months

Strain of the Tendo Achillis.—This affection may follow an un accustomed amount of walking or jumping and is characterised by pain in the region of the tendon near its insertion

The treatment is to apply a supporting bandage from the toes to the knee and to place a cork elevator inside the heel ¼ in. high posteriorly and tapered towards the anterior aspect These are retained for two to three weeks

Rupture of the Tendo Achillis.—Complete rupture of the tendon is not uncommon in athletes and accompanying the sudden pain of this injury there is loss of power in raising the heel

Treatment is to expose the tendon by a vertical incision and to suture it with catgut mattress sutures A plaster of Paris splint is then applied to include the knee in 90° flexion and the foot in plantiflexion This is retained for six weeks An elevator is worn in the heel of the shoe for a further four weeks

Sometimes the condition is not diagnosed at the time of injury and the patient walks with a flat-foot He has no spring in the gait and is unable to stand on his toes with the heel raised, although weak plantiflexion may be carried out using the long posterior tendons of the foot In such cases delayed suture should be performed A posterior vertical incision is made extending from the lateral aspect of the calcaneus upwards for 6 in. The gap in the tendon is located and the scar tissue excised The tendon of peroneus longus is now sought behind the lateral malleolus detached as far distally as possible and used as a living suture to close the gap Alternatively a suture of fascia lata may be used

The after-care is as described above except that plaster is retained for eight to ten weeks

AFFECTIONS OF THE FOREFOOT

Metatarsalgia.—Metatarsal pain, neuralgic in character and sometimes severe is associated with a variety of affections of the foot especially flat-foot claw foot and arthritis of the metatarso-phalangeal joints If the treatment of the primary condition fails to relieve the metatarsal pain special measures are necessary

A broad fitting shoe should be worn with a special dome and bar insole—the dome so arranged as to elevate the second and third meta tarsals and so raise the anterior arch the bar to relieve the arch from weight bearing

If this fails to bring relief manipulation under anæsthesia should be performed the toes being forced into full flexion and the anterior arch moulded upwards Plaster of Paris is then applied for six to eight weeks and subsequently the insole is worn as described above

Finally in resistant cases the head of the offending metatarsal bone should be excised through a short incision on the dorsum of the foot

March Fracture.—This condition generally affects the shaft of the second or third metatarsal bone and gives rise to pain and swelling in that region.

The treatment is to enclose the foot in a plaster case for four to six weeks Later an adhesive supporting bandage should be applied, with a metatarsal pad to support the anterior arch of the foot until consolidation occurs

Osteochondritis of the Metatarsals (*Köhler Freiberg Disease*) — *This* condition which is believed to be traumatic in origin affects the head of one of the metatarsals usually the second or third and gives rise to pain and swelling in that region X ray examination shows changes in the metatarsal head similar to those in the femoral head in Perthes disease

The treatment in the early stages is to encase the foot in plaster for six to eight weeks Subsequently a domed insole should be worn, or a *metatarsal bar may be applied behind the tread of the sole*

In late cases where there is arthritis of the metatarso phalangeal joint often with the formation of loose bodies operation should be performed *the head of the metatarsal being trimmed and the base of* the phalanx excised

Plantar Warts.—Warts occur commonly on the skin under the heel and under the metatarsal heads They may be distinguished from corns and callosities by their fragmented surface The treatment in the first place is to soften the wart by applying 5 per cent salicylic acid in spirit and thereafter to remove it with a sharp spoon Ethyl chloride spray provides sufficient anæsthesia for this purpose In resistant cases an application of radium or soft X rays often gives lasting relief A metatarsal bar or a sponge-rubber insole should be fitted to the shoe to protect the part from weight bearing

AFFECTIONS OF THE TOES

Hallux Valgus.—This common deformity may be symptom free or give rise to severe disability Often there is pain due to pressure by the shoe on the prominent medial aspect of the metatarsal head An exostosis is often present at this *point and an adventitious bursa* may develop over it forming a bunion which may be inflamed and may suppurate In severe cases secondary arthritic changes develop in the first joint of the great toe and lead to much pain



Fig 140

Hallux valgus with bunion, showing amount of bone to be removed.

In an *uncomplicated early case* the treatment is to provide footwear sufficiently wide to accommodate the very broad forefoot A digitated sock is helpful, and the shoe may be fitted with a separate compartment for the great toe A thin metal or fibre splint *convex in its* long axis accurately fitting and with a hollow corresponding to the metatarsal head may be *strapped to the medial side of the foot and toe*

In later cases operative treatment is required. Many types of

operation have been described but generally the choice lies between the two following procedures

In elderly patients with pain resulting from an inflamed bunion it usually suffices to remove the adventitious bursa and the prominent medial part of the metatarsal head with no attempt to correct the valgus deformity A straight or slightly curved incision is made through healthy skin on the dorso-medial aspect of the metatarsal region immediately above the bunion The lower flap is retracted and the bursa which may be greatly thickened is dissected out and removed The metatarsal is now cleared by means of a periosteum elevator Any exostosis present is removed by means of an osteotome, and the medial prominence of the head is also cut away The wound is then closed

In younger patients and in any case if the symptoms are attributable to arthritic changes the first phalanx is also exposed and cleared and divided by bone forceps at least ½ in from its base the proximal fragment being removed as in the operation for hallux rigidus The distal fragment is then trimmed smooth and to prevent new bone formation between the phalanx and metatarsal a flap of soft tissues taken from the medial aspect of the toe is interposed and sutured in place As an additional step to permit full correction of the deformity the tendon of the extensor hallucis longus may be divided by sub cutaneous tenotomy proximal to the site of operation

After this operation a firm bandage is applied with the toe in corrected position Active exercises may be begun in two to three days The patient is allowed up at the end of the third week A metatarsal bar should be fitted to the shoe to relieve the toe from weight-bearing If the patient is unable or unwilling to lie up a firm plaster shoe may be applied and walking allowed from the start

Hallux Rigidus.—This condition results essentially from traumatic arthritis of the first joint of the great toe The term rigidus is a



Fig 150
Hallux rigidus removal of base of proximal phalanx

misnomer for the joint can be flexed through the normal range but dorsiflexion is very restricted owing mainly to lipping and osteophyte formation on the dorsal aspect of the metatarsal head consequently rising on to the toes in walking causes much pain

The treatment in a mild case is to protect the joint from dorsiflexion strain This may be done by fixing a metatarsal bar behind the tread of the sole In acute cases a plaster case with a walking stirrup may be necessary

When these methods fail or in any case where there is marked arthritis, operation is indicated Of the many procedures devised the *most satisfactory is to trim the exostosis from the metatarsal head and to resect the proximal part of the first phalanx*

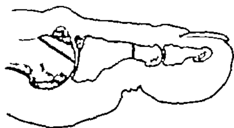


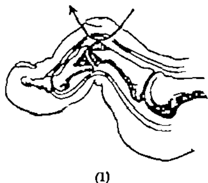
FIG 151

Hallux rigidus, showing amount of bone to be removed in a case with prominent exostosis on dorsum of metatarsal head

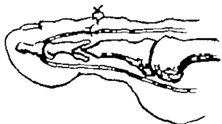
A longitudinal incision is made on the dorsomedial aspect of the toe (Fig 150) the proximal joint is opened and the first phalanx is exposed subperiosteally and presented *The phalanx is then divided* by bone forceps well down the shaft and the proximal portion which should comprise about two thirds of the entire phalanx is removed. The *metatarsal head is then trimmed* by the removal of any dorsal exostosis To prevent new bone formation in the line of the first phalanx a flap of soft tissues should be drawn in to occupy the space between the phalanx and metatarsal bone The wound is then closed The after treatment is the same as for hallux valgus.

Hammer toe.—*In this deformity*, which most often affects the second toe the metatarso phalangeal joint is dorsiflexed and the first interphalangeal joint acutely plantiflexed The dorsal prominence of the latter joint is surmounted by a painful corn which is the main cause of disability

Hammer toe may be associated with claw foot or with hallux valgus and these conditions may require their appropriate treatment In other cases the deformity may be attributed to the *use of short footwear*



(1)



(2)

FIG. 152

Hammer toe. (1) Removal of wedge of soft tissues including the corn. Portions of bone to be removed are shown black. (2) Operation completed.

In children the only treatment necessary is to provide a shoe long enough to accommodate the toe Later when deformity is of slight degree *local splintage with two bands* of adhesive strapping should be applied One band passes over the proximal phalanx and underneath the adjacent first and third toe The other acts as *a sling below the toe* beyond this joint and is fixed to the dorsal surface of the adjacent toes This is reapplied at intervals and maintained for two or three months

In adults operation is generally necessary It may be performed under local anæsthesia, but general anæsthesia is usually preferred. A transverse elliptical incision is made over the interphalangeal joint *excising the corn bearing skin The extensor tendon is divided* and the

joint entered The opposed ends of the two phalanges are then cleared and projected out at the wound and are removed by bone forceps sufficient being taken away to allow the ends to be apposed with the toe completely extended A useful method is to sharpen the end of the first phalanx to a point which is then driven into the base of the second phalanx thus fixing them rigidly in extension The severed tendon is then sutured with a single catgut stitch and the skin wound closed In some cases the extensor tendon must be divided by a tenotome at a point proximal to the operation site to allow the meta tarso phalangeal joint to be plantiflexed. Finally the toe is held in position by adhesive bands as de scribed above

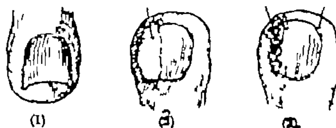


FIG. 153

Ingrowing toe-nail. (1) An uncomplicated case. Note that the nail is correctly cut. (2) Case complicated by paronychia. Note that the nail has been cut incorrectly Line of incision indicated. (3) Bare area packed with gauze.

Ingrowing Toe-nail.— This troublesome com plaint is due to the use of a tight shoe which presses the soft tissues against the side of the nail. The treatment in an early case is to provide a roomier shoe and a roomy stocking

The patient should be instructed not to pare the side of the nail for the sharp edge thus made cuts into the overlying soft tissues In some cases relief is obtained by packing strands of wool under the side of the nail with an orange stick to protect the soft tissues from pressure

If these measures fail operation should be advised except in the presence of acute inflammation, when fomentations should be ap plied. The operation may be performed under local anaesthesia but general anaesthesia is generally preferable The usual procedure is to resect a V-shaped portion of tissue including about one-third of the nail with its underlying matrix and the overhanging lateral skin edge The space thus created is then packed lightly with vaseline gauze and the raw area allowed to granulate Recurrence is frequent after this procedure and accordingly a more radical procedure is sometimes advisable the object of which is to excise the whole width of the nail bed For this purpose two short lateral incisions are made extending through the skin proximally from the two proximal corners of the nail. The rectangle of skin between the incisions is then dissected back. The whole nail is now avulsed and the nail bed excised by cutting away a wedge of tissue down to the bone.

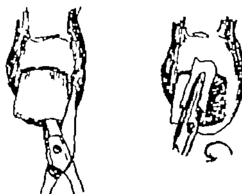


FIG 154

Avulsion of toe-nail.

An astringent such as 5 per cent tannic acid is applied to the raw area which is allowed to granulate

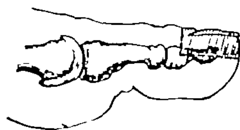


Fig 183

Amputation of distal part of great toe indicated for ingrowing toe-nail and other affections of nail and nail bed

An even more radical procedure often most satisfactory in its results is to remove the whole nail and nail bed along with the distal half of the phalanx An incision is made skirting the sides and free edge of the nail, and a plantar flap of skin and soft tissues is dissected off the bone The ends of this incision are joined by a straight dorsal incision proximal to the nail and deepened to the bone which is divided with cutting forceps and removed The plantar flap is then stitched to the skin of the dorsum

A M.

CHAPTER XXI

RADIOTHERAPY

RADIOTHERAPY now plays an important part in the treatment of malignant disease and various other conditions Its use is no longer empirical, but is based on ability to prescribe known doses and upon knowledge of their biological effects The radiations from radium or from X ray apparatus which are used in medicine differ from those of light heat or wireless waves in respect that the much shorter wave-lengths concerned endow them with special qualities These and the physical and biological principles of importance in radiotherapy are considered in the present chapter The technical details relating to the use of radiotherapy in individual lesions are described in the regional chapters

Close co-operation between radiotherapist and surgeon is essential to ensure the proper selection of cases The surgeon must be aware of the scope and effectiveness of irradiation so that suitable cases may be referred for consultation while the radiotherapist must combine technical skill with clinical judgment and knowledge of pathology

RADIUM

The element radium (Ra 226) owes its activity to the fact that its atoms are unstable and liable to undergo disintegration, with liberation of intense energy in the form of radiations capable of penetrating optically opaque material and of producing certain biological effects

The atoms of all elements are regarded as composed of a central positively charged nucleus surrounded by a number of negatively charged electrons the number being just sufficient to balance the positive charge on the nucleus The physical and chemical properties of the element depend on the integrity of this arrangement any change in the nuclear charge would therefore bring into being a new element In the case of radium a continuous series of changes takes place the first product being radon (radium emanation) a heavy and chemically inert gas and the others a number of solid elements The process terminates with the formation of stable radium G with atomic weight 206 and the properties of lead These phenomena are due to positively charged portions of the nucleus (*alpha particles*) and electrons (*beta particles*) leaving the atom The disintegration process is accompanied by the liberation of much radiant energy in the form of *gamma rays* which are true electromagnetic vibrations of very short wave lengths

Alpha particles are of no therapeutic value as their penetrative power is very slight Beta particles also are fairly easily absorbed, and have moreover only a caustic effect on living tissues which they destroy indiscriminately

Gamma rays on the other hand have great powers of penetration and also have a selective action on the tissues to which property they owe their therapeutic value Their use to the exclusion of alpha and beta particles is achieved by the use of filters These usually consist of platinum 0 6 mm in thickness which holds back the alpha and almost all the beta particles while offering little obstruction to the passage of gamma rays When sealed in suitable containers radium provides a practically constant supply of such radiations since it takes 1 600 years to decay to half of the original amount

X RAYS

X rays are generated in a special evacuated glass tube with electrodes at each end between which a high electric potential is applied Owing to the high vacuum the current will only pass when aided by electronic emission from a heated wire or filament The latter forms the negative electrode of the tube and according to well known electrical laws the electrons move to the positive electrode with great velocity which varies according to the voltage A metal target is placed in the path of these electrons and they give up their energy on impaction Most of the energy is dissipated as heat but a little is transformed into the electromagnetic waves known as X rays The radiations from an X ray tube include a wide range of wave-lengths, the minimum limit depending on the voltage applied The higher the voltage and thus the shorter the wave length the greater are the energy and penetrative power For voltages in normal use X rays in general have wave-lengths much longer than those of the gamma rays of radium The output of an X ray tube is rendered more homogeneous by the incorporation in it of filters to exclude the longer varieties which are less penetrative and more irritating to skin The majority of X ray therapy plants operate at 200 kilovolts Lower voltages and therefore less penetrative or softer rays may be used for some more superficial lesions and a newer development is the use of specially soft rays generated at about 60 kilovolts which are employed mostly for cutaneous lesions of superficial type (contact therapy)

GENERAL CONSIDERATIONS

The Distance Factor —All these radiations are subject to the law which states that their intensity varies inversely as the square of the distance from the source This law is constantly made use of in calculating amounts of radiation from single or multiple sources

When external radiation is being used, the skin must always receive a greater dose than the tumour below it and is thus liable to damage This risk can be diminished by removing the source of irradiation to a suitable distance for then although the output of radiations from the

source must be increased proportionately the relative excess of skin dose over tumour dose is reduced

The risk of damage to the skin may also be countered by the use of multiple ports of entry Thus the tonsil may be irradiated along six or eight beams each traversing a different area of skin on the face or neck and treating both the primary lesion and gland zones at once Each skin area has therefore to bear only a proportion of the radiation being delivered at the affected region This procedure is adopted both in the case of X ray therapy and radium beam therapy the ports of entry being marked on the skin with indelible paint which is left undisturbed throughout the whole course of treatment

Dosage.—The earlier methods of calculating dosage by milligram hours (radium) or by erythema dose (X rays) are now obsolete The physical unit of radiation now most generally used is the *roentgen* or *r* unit Both gamma rays and X rays have the power of ionising gases and this forms a basis for measuring them The roentgen may be regarded as indicated by the amount of ionisation produced under certain conditions in a unit volume of air during a unit period of time The estimation of the dose delivered from point to point in a given volume of tissue is only possible when such physical units are employed

Factors Modifying Dose Effects.—The effects upon the tissues and upon various types of tumour caused by different amounts of radiation are now well known Such effects vary greatly however according to how the dose is given Among the more important physical factors are the total time taken to deliver the dose and the rate of delivery Protraction of treatment permits higher dose levels to be attained with safety The effect of a given dose also tends to be greater when it is delivered to large volumes of tissue One consequence of this is that external radiation should be carried out through as small beams as possible Statement of a total dose delivered is meaningless unless qualified by such details

Different types of malignant disease vary greatly in their reaction to irradiation (degree of radiosensitivity) and knowledge of this must dictate the total dose aimed at in any given case The conception of a carcinoma dose has long been abandoned. In non neoplastic diseases the amount of radiation must be adjusted to meet individual requirements Other biological modifying factors of importance include the presence of local sepsis and proximity of the tumour to vital organs irradiation of which might cause undesirable effects In the latter category are the lungs and large parenchymatous organs such as the liver Good vascularity is essential if the tissues are to tolerate even normal doses Reduction in blood supply such as may occur from previous operation or other trauma or from previous irradiation may be a bar to further treatment Invasion of bone or cartilage alters the prognosis adversely

Some typical dose levels in the treatment of tumours may be stated subject to the qualifications just mentioned Using X rays at 200 kilovolts 4 000 *r* may be given in daily fractions over four weeks though such an amount may be exceeded when necessary with suitable protraction of treatment In the case of gamma rays a usual dose is

6 000 r and where local treatment of small volumes of tissue is involved this may be delivered in seven to ten days Irradiation of large volumes of tissue by external radiation (radium beam therapy) would demand protraction over about six weeks to deliver the same dose In *this case* daily doses may be given whereas local treatments can often be arranged to operate continuously over the total time involved

These dose figures refer to the total delivered at the tumour area (tumour dose) and not to the amount applied to any given skin area

Biological Effects of Radiation

If enough be administered these radiations will prove lethal to all tissues and so therapeutic doses must be kept below the levels known to be dangerous The action of gamma rays and X rays is

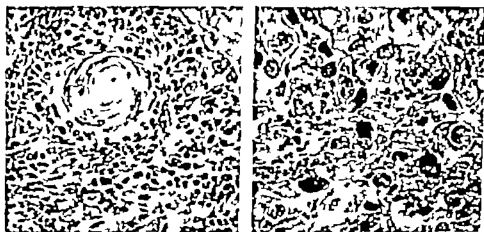


Fig 156

Effect of radium irradiation. Epithelioma of cervix uteri before and during treatment (both × 250).

selective and the cells most susceptible are those undergoing proliferative activity such as germ cells blood forming tissues and the skin The nucleus in mitosis is the most sensitive part this is why certain tumours respond to doses which are not lethal for surrounding tissues and why tumour response varies with the type of lesion

Irradiation of cells in tissue cultures causes swelling and slows or arrests mitosis In higher doses it leads to nuclear degeneration and even cell disintegration while such cells as survive may *later show* abnormal mitotic forms

Tissues examined *microscopically after irradiation* (Fig 156) show alteration in the shape and size of tumour cells granularity of cytoplasm, *and aberrant nuclear formations* there may be some leucocytic infiltration Later on the cells stain poorly and finally vanish as stromal reactions appear mainly in the form of increase in fibrous tissue and vascular changes of obliterative type It seems likely that in addition to such directly produced local changes the defence mechanism of the body may play a part in finally destroying damaged cells

Even when there is comparatively little naked-eye evidence that

full doses of radiation have been administered such changes would be evident microscopically and are naturally of a permanent character This explains why it is so often possible to deliver only one radical treatment which must therefore be planned and carried out with the utmost care

Irradiation exerts special effects on particular tissues The skin, after full therapeutic dosage shows erythema with dry desquamation and epilation and, after maximum treatment these changes progress to moist desquamation which may heal with later development of atrophic change and even telangiectases In the case of mucous membrane a grey film of fibrinous exudate appears

The hæmopoietic tissues are susceptible and after a certain exposure is reached there may be leukopenia as well as some anæmia The blood vessels sustain endothelial damage and after initial congestion thrombosis may result especially in those of small calibre a later change is some degree of obliterative endarteritis The secreting glands and certain ductless glands suffer depression of their activity and this explains the dry mouth after extensive irradiation in that region

Finally in addition to such local reactions patients having more than small volumes of tissue treated may suffer some constitutional upset one of the most important manifestations of which is radiation sickness This is most often seen after treatment of the upper abdomen or mediastinum

Indications for Radiotherapy

Radiotherapy is used in many unrelated *non malignant conditions* too numerous for detailed mention here and in some of these it is the treatment of choice In many cases irradiation is designed not to cure the disease directly but to influence it indirectly by stilling the activity of the tissues involved Thus benefit is gained in ringworm by causing temporary epilation in parotid fistula by diminishing secretion in chronic mastitis by reducing mammary hyperplasia and in some uterine conditions by sterilising the ovaries

The various forms of *malignant disease* may be roughly classified in three groups according as radiotherapy is preferable to surgical extirpation is useful as an alternative or as an auxiliary measure or is unlikely to be effective There can be no hard-and fast line between such groups which tend to overlap and radiotherapists are constantly working to place more and more cases into the first category

Irradiation is generally preferable to excision in tumours of the skin (except melanoma) of the mouth of the accessory nasal sinuses and of the cervix uteri The most important representative of the second group is carcinoma of the breast in which radiotherapy is an important auxiliary to radical operation and moreover has a definite place as a primary treatment particularly in cases unsuited for operation Finally there remains the group in which radiotherapy is unlikely to be effective either owing to the nature of the tumour itself or to various complicating circumstances Here are included most tumours of the digestive tract from salivary glands to rectum (except perhaps of œsophagus) primary tumours of lung most ovarian tumours most

6 000 r and where local treatment of small volumes of tissue is involved, this may be delivered in seven to ten days Irradiation of large volumes of tissue by external radiation (radium beam therapy) would demand protraction over about six weeks to deliver the same dose In this case daily doses may be given, whereas local treatments can often be arranged to operate continuously over the total time involved

These dose figures refer to the total delivered at the tumour area (*tumour dose*) and not to the amount applied to any given skin area

Biological Effects of Radiation

If enough be administered these radiations will prove lethal to all tissues and so therapeutic doses must be kept below the levels *known to be dangerous* *The action of gamma rays and X rays is*

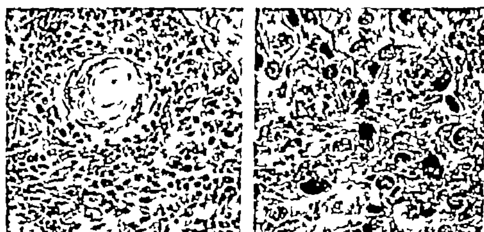


Fig. 156

Effect of radium irradiation. Epithelioma of cervix uteri before and during treatment (both × 230)

selective and the cells most susceptible are those undergoing proliferative activity such as germ cells blood forming tissues and the skin The nucleus in mitosis is the most sensitive part this is why certain tumours respond to doses which are not lethal for surrounding tissues and why tumour response varies with the type of lesion

Irradiation of cells in *tissue cultures causes swelling and slows or* arrests mitosis In higher doses it leads to nuclear degeneration and *even cell disintegration* while such cells as survive may later show abnormal mitotic forms

Tissues examined microscopically after irradiation (Fig 156) show alteration in the shape and size of tumour cells granularity of cytoplasm and aberrant nuclear formations there may be some leucocytic infiltration Later on the cells stain poorly and finally vanish as stromal reactions appear mainly in the form of increase in fibrous tissue and vascular changes of obliterative type It seems likely that in addition to such directly produced local changes the defence mechanism of the body may *play a part in finally destroying* damaged cells

Even when there is comparatively little naked-eye evidence that

full doses of radiation have been administered such changes would be evident microscopically, and are naturally of a permanent character This explains why it is so often possible to deliver only one radical treatment which must therefore be planned and carried out with the utmost care

Irradiation exerts special effects on particular tissues The skin after full therapeutic dosage shows erythema with dry desquamation and epilation and after maximum treatment these changes progress to moist desquamation which may heal with later development of atrophic change and even telangiectases In the case of mucous membrane a grey film of fibrinous exudate appears

The hæmopoietic tissues are susceptible and after a certain exposure is reached there may be leukopenia as well as some anæmia The blood vessels sustain endothelial damage and after initial congestion thrombosis may result especially in those of small calibre a later change is some degree of obliterative endarteritis The secreting glands and certain ductless glands suffer depression of their activity and this explains the dry mouth after extensive irradiation in that region

Finally in addition to such local reactions patients having more than small volumes of tissue treated may suffer some constitutional upset one of the most important manifestations of which is radiation sickness This is most often seen after treatment of the upper abdomen or mediastinum.

Indications for Radiotherapy

Radiotherapy is used in many unrelated *non malignant conditions* too numerous for detailed mention here and in some of these it is the treatment of choice In many cases irradiation is designed not to cure the disease directly but to influence it indirectly by stilling the activity of the tissues involved Thus benefit is gained in ringworm by causing temporary epilation in parotid fistula by diminishing secretion in chronic mastitis by reducing mammary hyperplasia and in some uterine conditions by sterilising the ovaries.

The various forms of *malignant disease* may be roughly classified in three groups according as radiotherapy is preferable to surgical extirpation, is useful as an alternative or as an auxiliary measure or is unlikely to be effective There can be no hard-and fast line between such groups which tend to overlap and radiotherapists are constantly working to place more and more cases into the first category

Irradiation is generally preferable to excision in tumours of the *skin* (except melanoma) of the mouth of the accessory nasal sinuses and of the cervix uteri The most important representative of the second group is carcinoma of the breast in which radiotherapy is an important auxiliary to radical operation and moreover has a definite place as a primary treatment particularly in cases unsuited for operation. Finally there remains the group in which radiotherapy is unlikely to be effective either owing to the nature of the tumour itself or to various complicating circumstances Here are included most tumours of the digestive tract from salivary glands to rectum (except perhaps of œsophagus) primary tumours of lung most ovarian tumours most

neoplasms in the urinary tract and nearly all bone tumours Possibilities for palliation exist in many of these instances

METHODS OF RADIOTHERAPY

Radium —Radium may be applied in needles introduced into the affected part (interstitial method) on apparatus applied to the surface of the body in apparatus placed within certain body cavities (cavitary method) or from a distance (teleradium therapy or radium beam therapy)

Radium needles made in various lengths to suit individual requirements, have a platinum wall which acts as a filter They usually contain radium sulphate which is uniformly distributed throughout the active length in an amount depending on the required output as measured in roentgens



FIG 197

Radium beam therapy for buccal carcinoma and glands. Skin markings indicate ports of entry and two of the fixed points (shown by crosses) where the central axes of beams for the opposite side emerge

Homogeneous irradiation of the part is never possible but with careful planning the maximum and minimum dosage will be such as to give a good result Interstitial treatment or implantation of radium is used mainly for carcinoma of the tongue lip skin and anus *occasionally for the breast and* after surgical access for intrinsic laryngeal lesions and some tumours of the bladder Suitable threads are attached to the needles for withdrawal at the conclusion of treatment

Surface applications are made by fixing radium needles or tubes on apparatus composed of dental compound or other suitable material which can be moulded accurately to the affected part (Fig 204) The needles are arranged to give a homogeneous field and their distance from the skin will depend on the depth to which the dose must be delivered The possible depth to which treatment may be given with surface apparatus is limited by the large amount of radium required as distance from skin is increased, and by the constitutional effects which follow such increase

The *cavitary method* utilises radium containers embodied in apparatus made of vulcanite or some dental compound and is used especially in carcinoma of palate floor of mouth lip and buccal aspect of cheek In some of these cases the physical requirements call for a combined surface and cavitary method, so that dosage may be uniform With special apparatus the method is also used for tumours in the maxillary

antrum after removal of its bony wall and for carcinoma of the cervix uteri

In these three methods the zone of effective dosage is relatively small and their applicability depends largely on the extent and accessibility of the lesion as well as on how radium may be placed and maintained in position

The *radium beam method* utilises a specially protected unit from which only a single beam is permitted to emerge (Fig 158) The radium is at a distance from the skin so that a better dose at depth is obtained than by the preceding methods Such increased distance demands large amounts of radium to keep up the dose rate and 1 to 10 gm may be required according to the nature of the apparatus and what is

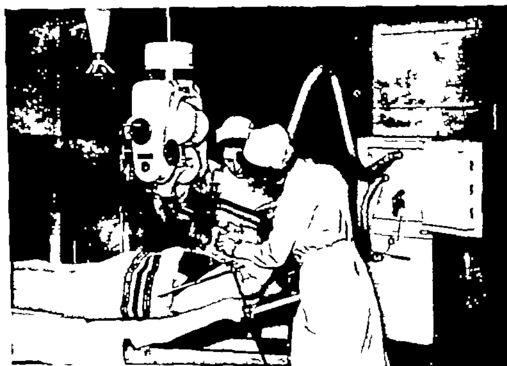


FIG. 158

Radium teletherapy Beam unit at Western Infirmary Glasgow Radium stored in the lead safe (seen on right) is delivered through the pneumatic tube to the overhead apparatus when all adjustments have been made

desired of it The required dose is usually built up by introducing the radiation through multiple ports of entry so as to diminish skin exposure on any one area of skin as compared with the total tumour dose at depth contributed to by all. The method does not supplant local treatment with radium but rather increases the sphere of effective treatment possible The amounts of radium so far available have tended to limit the method to more inaccessible growths in the head and neck region such as tumours at the base of tongue or in the pharynx Treatment is by daily doses in distinction to that by other radium methods where continuous exposure is often given

Radon.—If a solution of radium salt be placed in a sealed vessel the first disintegration product—radon gas—may be pumped off from time to time and placed in suitable containers The same radiations

as have been described in the case of the parent radium are given off before this radon decays to radium G but the output is a rapidly falling one since no radium is present to maintain a balance between the processes of formation and disintegration Radon falls to half strength in 3 82 days and has almost completely decayed in a month. Tiny platinum or gold containers (radon seeds) are frequently employed and are useful in situations awkward either owing to inaccessibility or contour A special introducer is necessary and the seeds may be left in place permanently

X-rays.—Treatment with X rays provides an example of external radiation The mixture of wave-lengths coming from any X ray tube is filtered so as to eliminate the less penetrative varieties and the



FIG 150

X ray therapy Unit at Western Infirmary Glasgow

multiple field method is in general use for all deeply seated lesions. A typical X ray tube (Fig 159) is enclosed in a shock proof and protective casing An applicator limits the rays and directs them on to the patient The quality of X rays will depend upon the potential applied to the tube X rays can be produced in much greater quantity than gamma rays since the amount depends merely upon the electrical characteristics of the generating apparatus It follows that the distance from the source (the target) to the skin can readily be increased with consequent improvement in the dose at a given depth in the tissues In spite of the less penetrative quality of X rays as compared with those from radium this increased proportion between tumour dose and skin dose enables one to treat even the most deeply placed neoplasms by X rays Limitations are however imposed by constitutional effects

For the treatment of malignant disease a generating potential of about 200 kilovolts is most often used, as this provides radiation which is usually sufficiently penetrating, a new development is that of supervoltage X rays which render available wave lengths more like those emanating naturally from radium Already one such set operates regularly in this country at 1 000 kilovolts and by its use better results have been claimed in the treatment of rectal carcinoma than have previously been recorded In all cases careful calculations and planning are necessary to ensure that the area being treated receives an adequate and reasonably homogeneous dose without any part including the skin receiving more than it can tolerate The total doses given in the treatment of malignant lesions demand splitting of the dose into fractions given daily over a period of weeks they could not otherwise be tolerated by the patient or tissues The multiple field method already described is usually necessary where the lesion is at any depth in the body

More superficially placed lesions may be conveniently dealt with by the use of less penetrating X rays such as those generated at potentials of 140 to 160 kilovolts (medium X ray therapy) A special method falling into this group is that of applying X rays by so-called *contact therapy* The rays are generated at about 50 or 60 kilovolts in a special tube having its target close to the skin they have very little penetrative power and the dose rapidly falls off as the radiation enters the tissues High dose rates from such an apparatus are possible and therefore much radiation can be given in a short time The small amount of tissue treated makes it unlikely that constitutional upset will appear besides assisting the body to tolerate the local dose The method is specially indicated for superficial skin lesions and where these are of radiosensitive type (basal cell carcinoma) a single exposure may suffice the dose being correspondingly lowered. It has also been used for growths inside the mouth at the cervix uteri and after suprapubic cystostomy in the bladder

Different in character is the treatment of diffuse or generalised lesions of highly radiosensitive type by the X ray bath Here the whole thorax or abdomen or both may be exposed to the rays usually in cases of seminoma testis with metastases lymphadenoma or chronic leukaemia The risk of constitutional upset is great and only small doses can be given at a time without constant examination of the blood as a safety measure

Planning the Treatment

When it has been determined that a case is suitable for radiotherapy it must be decided whether treatment should aim at being curative or merely of a palliative nature to relieve symptoms If radical treatment is to be undertaken the total dose to be delivered is assessed in view of the clinical and pathological facts and then the most appropriate method of administering it is decided It must be realised that there is virtually only one chance of cure even with responsive malignant lesions since post radiational changes will seriously interfere

with the tolerance of the tissues and with the reaction of the growth to any further radiotherapy The amount of radiation delivered must not fall short of what is believed to be lethal for the neoplasm in question and it must be delivered as accurately as possible to the whole tumour zone including the lymphatic drainage area in most cases The usual rule is that the more anaplastic the tumour the lower the dose to which it will respond This is a fortunate circumstance since the scheme of treatment for such a lesion is likely to involve irradiation of a greater volume of tissue than could be safely raised to the higher dose level Such decisions are dictated by pathological considerations of the increased tendency to regional metastases and the obvious need of including the whole potentially affected zone in the treatment On the other hand the more differentiated lesions call for higher dose levels which may only be attainable either by the local use of radium or by multiple small field radium beam or X ray therapy directed as already described to a comparatively small volume of tissue Such higher doses are achieved by keeping the skin dose as low as possible while centering the aggregate effect of the various ports of entry upon the tumour site In the case of radium the same effect is achieved by implanting needles or devising some form of cavitory application It should be clear from the foregoing statements that the planning of treatment must include as a first essential the most careful clinical and pathological assessment of the patient and of the neoplasm from which he suffers

The more anaplastic lesions are rarely amenable to surgical treatment and are generally a radiotherapeutic problem but in the case of mammary carcinoma of this grade of malignancy surgery may constitute a useful or even essential sequel to irradiation The more normal grades of mammary carcinoma are on the other hand a surgical problem primarily although radiotherapy *is a very useful adjuvant* thereafter

General Care of the Patient

When a fair volume of tissue has to be subjected to full doses of radiation the patient must be prepared no less thoroughly than for a major operation The general condition may require attention and any anæmia rectified by administration of iron or even by transfusion while the nutrition must often be improved

Local sepsis is cleared up as far as possible since it might become worse under irradiation and introduce complications Ulcerating growths if accessible are treated with suitable antiseptics of which the most effective is proflavine oleate (1 per cent in liquid paraffin) this preparation has the advantage of being suitable for use even during treatment In carcinoma of the mouth and throat, septic teeth should be removed before treatment the trauma of extraction afterwards might precipitate bone necrosis even where perfectly normal doses had been given A mouth wash of acriflavine (1 5 000) is helpful

During treatment the general condition must be watched and the patient weighed regularly Frequent blood counts are usually necessary

The most sensitive blood cells are the leucocytes and if leukopenia appears, sodium pentnucleotide is advised Where much discomfort exists sedatives may be required to ensure sleep General constitutional effects may be manifest by deterioration in the general condition, either through direct radiation effects or owing to secondary causes such as reaction in the throat causing increased dysphagia during treatment of a lesion there Radiation sickness may also be encountered and, when not due to absorption of toxic products from a rapidly dis appearing tumour may be helped by intramuscular injections of liver extract Nicotinic acid given by mouth (100 mgm dissolved in water) is also useful

After treatment irradiated skin requires special care It should be kept dry and cleaned only with spirit and powdered as well as protected from friction or pressure The onset of moist desquamation may sometimes be retarded or prevented by frequent painting with 0 5 per cent each of brilliant green and methyl violet in spirit Should moist desquamation be considerable an oily dressing may be necessary such as the proflavine oleate preparation or 1 per cent ammoniated mercury in lanolin or vaseline Preparations of tannic acid are sometimes used or boracic powder dusted over a skin of dry protective tissues and then covered by gamgee tissue and a bandage

The mucous membrane in the mouth and throat is tender after irradiation of these parts through formation of the fibrinous film already described Any bland mouth wash is good and the parts are soothed by an occasional teaspoonful of liquid paraffin or honey which also relieves the dry mouth encountered at a later stage Simple analgesics may be required during the reaction period which may last for some weeks local anaesthetics like cocaine may be called for if the area involved is considerable

When treatment is given in the proximity of the eye this organ shares in the reaction and conjunctivitis will appear The eye must be kept uncovered and drops of acriflavine (1 3 000) used regularly Irradiation of the abdomen may cause irritability of bladder or bowel but this is temporary and can easily be controlled by symptomatic treatment

Late Sequelæ of Radiotherapy

Properly conducted radiotherapy should not cause obvious damage to the tissues but they may be more than usually susceptible to trauma and will be slow to heal thereafter Apart from some atrophy in the skin and epilation no late changes may be seen unless in an effort to cure some awkwardly situated or resistant growth, an unusually heavy skin dose has had to be applied. The resulting moist desquamation may be slow to heal and there may develop some degree of scarring and of telangiectasia the part may afterwards show some chronic œdema Only if normal dosage limits are transgressed or the modifying factors disregarded, will sloughing appear but trauma from any cause may precipitate limited sloughing in fully irradiated skin. Such sloughs which result from an extreme degree of vascular obliteration are painful and may take a long time to separate leaving callous

ulcers They should be treated primarily with bland ointment or various antiseptic preparations according to the circumstances encountered while every attempt is made at the same time to improve the general condition Later it is often desirable in a bad case to remove the affected skin including the slough and surrounding area of avascular tissue by the diathermy knife Mucous membrane may show pallor according to the degree of scarring and telangiectases when the dose has been high

Operation interference in radiated tissue should only be undertaken with caution and stitches left in longer than usual Further irradiation is generally undesirable as discussed above

New Developments in Radiotherapy

In the space available it has only been possible to give an outline of some of the main features of radiotherapy yet a word on the development and organisation of this important line of treatment may not be out of place All are now agreed that the best results can only be achieved through co-ordination of all forms of X ray and radium therapy so that the best method for the individual case can be selected without prejudice and applied efficiently The diverse and expensive forms of apparatus which are therefore necessary as well as the shortage of trained radiotherapists inevitably call for centralisation in large and fully equipped hospitals Such concentration of resources will also appear essential when it is recalled that surgery is the method of choice for quite as many varieties of cancer as is radiotherapy and that for others again some carefully planned combination of the two methods may be called for An impartial decision will be most readily arrived at in an institution where full consultation is taking place between physicians surgeons radiotherapists and specialists in general The fullest co-operation is essential and in all cases a clear line of treatment must be decided upon in the light of all the evidence before anything is done to the patient A further clinical point hardly touched upon here is that an increasing number of simple conditions call for special radiotherapeutic methods and full understanding between the various departments concerned is again essential

Finally the possibility of generating radiation by a novel method exists in the use of the *betatron* an apparatus providing electrons travelling at speeds equivalent to those which could be obtained by kilovoltages far beyond the range of ordinary X ray apparatus and still more widely known is the *cyclotron* through which neutron therapy may be made available in the future No opinion can be passed as yet on the clinical applications which may eventuate from the use of this ingenious device These include not only neutron therapy but the use of new radio-elements manufactured by the apparatus Such new elements are temporarily radio-active and can be used in the body both therapeutically and as tracers to assist in the elucidation of biological processes.

A. A. C.

those fashioned some distance from the recipient area are termed pedicle flaps

Homografts —The question of whether or not the transplantation of skin from one individual to another is a practicable procedure is often debated. Holman considered that cross grafts served as sources of foreign protein intoxication and led to the development of a reactive like anaphylaxis

When a human is twice homografted from the same donor source the grafts of the second planting break down more rapidly than their predecessors Appararently an immune factor is produced. Gibson and Medawar in their complete clinical experiments concluded that though homografts took perfectly in due course they were destroyed.



FIG 160
Relative thickness of free grafts

Homografts however in extensive burns and extensive skin loss may form a very useful—sometimes life saving—temporary dressing

Barrett Brown has reported the successful permanent homografts in identical twins

INDICATIONS FOR USE OF FREE GRAFTS

Thiersch or Thin Razor Grafts are used mainly where mucous membrane has been lost for example in the mouth in eye sockets and in the urethra Their weakness is a tendency to wrinkle and contract *Indications* Loss of buccal sulcus loss of airways contracted eye sockets and certain urethral conditions *Donor sites* The inner side of the upper arm

Thick Razor Grafts are applied to fresh or old raw surfaces The latter should undergo a preliminary cleansing course with frequent moist antiseptic dressings for example of half strength eusol A thick razor graft has less tendency to contract than a thin razor graft this tendency persists for 8 weeks during which the graft must be stretched *Indications* Traumatic wounds granulating areas cicatricial contraction of the upper eyelids X ray burns of the face and neck loss of whole skin on the body or limbs for example the skin of the hands and for the correction of webbed fingers *Donor sites* The inner side of the upper arm any aspect of the thigh or buttock the abdomen and the back.

Full Thickness Grafts are used in the repair of injuries of the face The full thickness graft is more flexible and of better texture than razor grafts, and does not contract It cannot be applied to large raw surfaces because the size required is prohibitive while on contaminated surfaces the take of a full thickness graft is not as certain as that of a thick razor graft *Indications* Ectropion of lower lids loss of a small portion of the facial skin when a good cosmetic effect is necessary *Donor sites* The post auricular skin the upper eyelid the inner side of the arm the front of the chest, the outer aspect of the thigh, the abdomen

Deep Pinch or **Staige-Davis Grafts** are 0·5 cm in diameter and are whole thickness in the centre and epidermal at the circumference The donor skin is raised by a needle point and removed with a scalpel *Indications* Granulating surfaces where there is doubt as to the receptiveness of the area *Donor site* The skin in the region of the crest of the ilium because after the removal of deep pinch grafts the donor site is rendered useless for further plastic procedures

Technique of Cutting Free Grafts

The thick razor graft is the most generally useful form of free graft A sharp knife is an absolute essential Free grafts are cut either

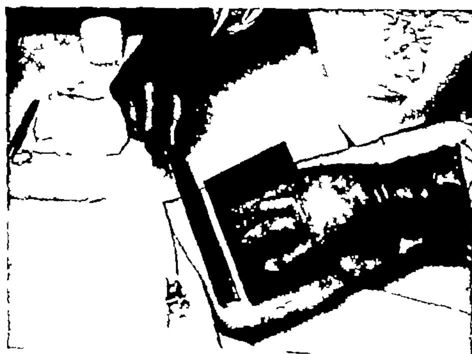


Fig 161
Cutting a razor graft.

free hand with a special (Blair) knife or razor, or mechanically with a Padgett dermatome

Razor Graft.—Both inner and outer side of the thigh can be used The edge of a wooden board and the under-surface of the blade of a Blair knife are lightly coated with vaseline A smooth field is sought on the flexed thigh the surgeon applies the board and the knife

proximally and begins to cut The board keeps the skin flat and tense, it is advanced slowly about 1 in in front of the knife The knife, hand wrist and forearm are held stiff the sawing action is controlled from the elbow which is kept close to the side As the knife travels distally the graft falls over the blade the cut graft is laid on tulle gras epidermal surface down and its raw surface is covered with gauze wrung out of warm normal saline solution The donor area is immediately dressed with tulle gras gauze swabs wrung out of saline wool and a firm sterile domette bandage A strip of adhesive plaster from skin to bandage prevents movement of the dressing

The thick razor graft is commonly applied in one piece but it can be cut up into narrow strips or postage stamp squares Postage

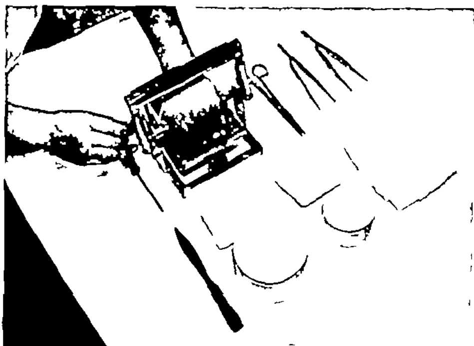


FIG 10.
A dermatome.

stamp grafts have to some extent taken the place of the deep pinch or Staige Davis grafts

Dermatome Graft.—The Padgett dermatome is an instrument by which grafts of known extent and thickness can be cut with accuracy from almost any skin surface It consists of a half drum with a knife set against its outer surface The distance between the knife edge and the drum surface can be controlled. The drum and the donor skin are painted with adhesive cement when the cement is almost dry the drum is applied evenly to the donor area to permit uniform adherence and a graft of measured size and thickness is cut Grafts can be taken from the back, abdomen or chest as well as from the limbs It is well to remember that the skin of the inner side of both the upper arm and the thigh is thin and if adequate care is not taken a full thickness graft is removed with the result that the donor area itself will require to be grafted

Failures of take of Free Grafts.—The cause can usually be found from one of the following improper immobilisation of the part inadequate or extreme pressure and infection

Movement encourages invasion of surface infecting organisms and leads to shearing of the minute nourishing vessels passing into the transplant

Inadequate or irregular pressure permits the accumulation of blood or serum beneath the graft Extreme pressure prevents vascularisation

Infection from penicillin or sulphonamide sensitive organisms are relatively rare Infection with resistent organisms such as *Bacillus proteus* and *Pseudomonas pyocyanea* leads to profuse discharge and the floating off of the transplants

Preservation of Skin Grafts.—Refrigerated skin grafts are of value in young debilitated or extensively burned patients The sources of the grafts may be cadavers amputated limbs as homografts or autografts or the usual donor areas on the trunk or limb of the patient himself or of others

Webster suggests that refrigeration of skin should be more widely used (*a*) to store excess remnants of grafts for possible future use (*b*) to delay grafting until suitable conditions of the recipient area prevail and (*c*) to divide long hazardous operations into two or more less taxing stages

Activation and De activation of Free Grafts.—If graft beds are the better for being in a receptive state it might be assumed that grafts themselves would benefit by activation Medawar on the other hand, suggested that free skin grafts especially if whole thickness, should be deliberately de activated in order to lower their metabolic demands during the critical stage of vascularisation

The length of time which skin can survive in the absence of food and oxygen is dependent on its temperature The higher the temperature the shorter the time of survival If some form of dressing could be devised which would keep the graft surface only a little above the temperature of the room the survival time of the graft might very well be more than doubled.

Indications for Use of a Skin Flap

A flap is used to repair a loss involving more than skin The pad of subcutaneous tissue is useful in replacing tissues over surfaces normally exposed to weight bearing or to friction and in covering exposed tendons nerves and bones

Local Flaps.—*Advancement or Sliding Flaps*—Only in the neck can a straight advancement be employed with advantage The VY' type of advancement is useful generally as a relaxation incision to permit the closure of small defects or apertures

Rotation Flaps.—In this type a large area of skin adjoining a defect is partly or completely undermined. An incision is then made to form a broad based flap which rotates over the defect When possible the secondary defect which is covered if necessary

with a razor graft, is planned to fall in some less obvious part This is the most useful of all local flaps

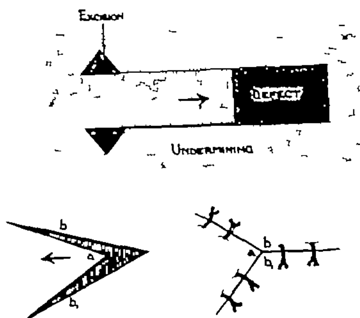


Fig 164
Straight and V Y advancement flaps.

Transposed Flaps.—In this type a flap of skin at right angles to the defect is raised and transposed. It is used for defects in the infra orbital region and about the mouth. The secondary defect is closed directly Another form of transposition is that employed in the Z plastic operation it may be used when there is webbing in the

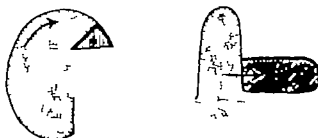


Fig 165
Rotation and transposed flaps.

neighbourhood of flexures An incision is made along the web at each end, on opposite surfaces of the web a triangular flap is raised, and one transposed with the other to allow the main suture line to lie at right angles to the original line of tension (see Fig 166)

Pedicle Flaps.—*Bridge or Pedicle Flaps* —The forehead rhinoplastic flap is a common example (see Fig 167) The pedicle is retained for two to three weeks when the flap will be receiving adequate nourishment from the recipient bed it is then returned to its original position

Direct Flaps.—Flaps may be transferred direct from the thorax or abdomen to the upper extremity, or from one leg to the other (cross leg flap) The secondary defect is covered with a razor graft

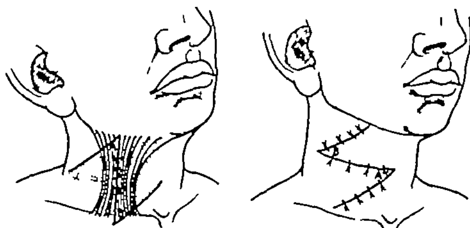


Fig. 166
Z plastic.

Tubed Pedicle Flap.—In Britain this flap has been perfected by Gillies By this method large flaps of skin and fat can be transported with safety from the chest and abdominal wall to sites far distant by way of an intermediate attachment for example the wrist When the pedicle reaches the final destination, it is untubed Tubed pedicles can be raised in several sites for example the lower oblique abdominal (5×2½ in or 5×3 in.) thoraco-epigastric (6×3 in.) thoraco-acromial (5×2½ in.) and cervical (5×2 in) (see Fig 169)

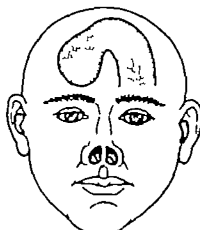


Fig 167
A forehead rhinoplasty

Technique of Raising Skin Flaps

Direct Pedicle Flap.—To plan the necessary stages in this procedure the completed operation is envisaged and the order of the steps reversed Thus to transfer an abdominal flap to the forearm the pattern of the defect is attached to the forearm (the final stage) the forearm is approximated closely to a suitable site on the abdominal wall, the superior or inferior edge of the pattern is raised from the forearm and attached to the abdomen and the forearm is then swung from the abdomen and the pattern allowed to fall accurately on that part of the abdomen which will form the forearm flap (the first stage) At the first operation, the flap is raised and attached to the forearm and the secondary defect on the abdomen covered with a razor graft At the second operation three weeks later the flap is detached from the abdomen and its attachment to the forearm completed

(see Fig 108) The planning and execution of the transfer of skin and fat from one leg to the other (the cross leg flap) is carried out in a similar fashion

Tubed Pedicle Flap.—A pedicle of skin is raised from the neck acromio pectoral region lower abdomen or other suitable area and

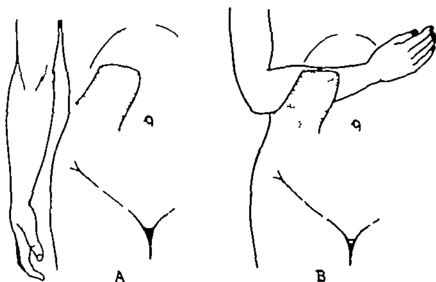


Fig 168
A direct flap.

after removing excess of fat its edges are approximated by a continuous fine silk stitch The edges of the resultant defect are undermined freely and closed in layers by direct approximation After three

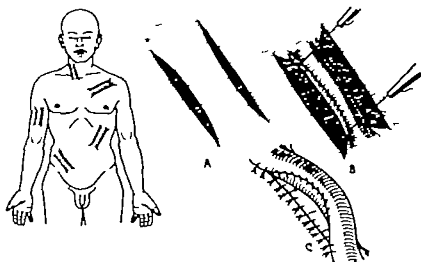


Fig 169
Tubed pedicles.

weeks time the medial attachment of the tube is severed and stitched to the intermediate host for example the forearm and after a further three weeks the lateral end of the tube is *detached*. The tube pedicle can then be conveyed to almost any part of the body by the inter mediate host

A precise knowledge of both the arterial blood supply and the venous drainage of a pedicled flap or tube at each stage of its transfer has two advantages (1) The periods of waiting between the stages of the transfer can be reduced—sometimes by half (2) Pedicles can be divided with confidence

Hynes has elaborated the atropine absorption test which provides a simple method of estimating the blood supply of a given tissue both qualitatively and quantitatively The only requirements are atropine a watch to estimate the pulse and a newspaper to test the ability to read.

To carry out the test a tourniquet is applied to the attachment of the flap or tube which is to be severed An injection of 1/75 gr of atropine dissolved in 0 2 c c of water is made just deep to the skin distal to the tourniquet The pulse rate is estimated every five minutes the time noted when the patient can no longer focus on the newsprint and the time noted of tingling in the lips followed by a feeling of increasing dryness in the mouth throat and larynx The pulse-rate rises in ten to twenty minutes the reading test may appear in fifteen minutes, and the dry mouth in about ten to fifteen minutes If the test proves *positive the tube or flap may be detached with safety if negative* interference should be delayed

PLANNING OF A PLASTIC OPERATION

The plan to be adopted will depend on many circumstances for example the extent and depth of injury the nature of tissue lost and the age and sex of the patient , the following is the order in which the types of repair are considered (1) *Flaps* from the immediate neighbourhood which are advanced transposed or rotated that is straight advancement, transposition and rotation flaps Another example is the ' Indian ' type of flap from the forehead to reconstitute the nose cheeks or lip (2) *Flaps* from a distance applied directly for example from chest to arm or with a tubed pedicle (3) Flaps transferred on an ' intermediate host ' usually the arm This is essentially the ' Italian ' method (4) *Free grafts these may be of skin, fat,* fascia bone or cartilage

Choice of Anæsthetic.—Many plastic procedures can be performed under local *anæsthesia,* produced by infiltration of the area or of the line of incision or by nerve block A 2 per cent or 0·5 per cent solution of novocaine with 8 minims of adrenaline hydrochloride to the ounce, is satisfactory not more than 150 c c is injected. In some rhinoplastic procedures the interior of the nose is anæsthetised with a solution of 10 per cent cocaine in a 1 2000 adrenaline hydrochloride solution applied on pledgets In certain patients and in most major plastic procedures inhalation anæsthesia is employed, and whenever possible an intratracheal tube is passed. Cyclopropane is favoured by some anæsthetists while others employ intravenous *pentothal* followed by *gas and oxygen* with a little ether

Preparation of the Field.—Infection is one of the greatest enemies

of a fine plastic result, and preparation of the field must be scrupulous The evening before operation hair in the region must be washed and cut short the operative field is painted with cetrimide 1 to 5 per cent and covered with a sterile towel, which is removed in the operating theatre, when the area is once again painted with Cetavlon or spirit Preparation of the face is similar In operative procedures on the nose the vibrissæ are cut It is unwise to shave any area since shaven hair bearing skin might inadvertently be manipulated to cover areas where hair is undesirable

Operative Technique

Gentle handling of tissues is an absolute necessity Skin flaps and grafts are handled by swabs moistened with normal saline or are held by fine tissue hooks

Incisions.—Incisions are made at right angles to the skin with a sharp knife

Hæmostasis.—Since hæmatoma formation prejudices the life of free grafts and flaps complete control of bleeding is essential The local application of thrombin, and pressure dressings are helpful in controlling oozing to control bleeding from larger vessels fine artery forceps and fine catgut or silk are used. Where hæmorrhage has been difficult to control a small drain is left for twenty four hours

Superficial Wounds without Skin Loss—Abrasions with impregnated foreign material from road surfaces are common Wound cleansing is difficult but this is no reason for inadequacy of effort One of several methods can be adopted (*a*) soaking with vaseline followed by cleansing with soap (*b*) removal of individual particles with a needle (*c*) sand papering (*d*) light brushing with a soft brush

Lacerations without skin loss can be closed primarily The necessity for excision of the skin edges depends on the amount of bruising and is *seldom necessary*

Sutures.—To produce a good scar severed muscle and subcutaneous tissue must be carefully approximated in turn with plain 3/0 or 4/0 catgut with the knots tied on the deep aspect

For the skin braided silk 0 006 in and *0·009 in are inserted close to the wound* margin and removed on the third to fifth day to avoid cross-stitch marks A curved-eyed or preferably eyeless needle (size 3 or 6) is used, threaded with fine silk, and the sutures are spaced about ¼ in. from each other Where there is a V-shaped wound the apical stitch is inserted into the skin of the outer edge brought subcutaneously through the tip of the V and then out from the skin of the opposite margin. By tightening the stitch the V is brought snugly into position a stitch inserted through the skin

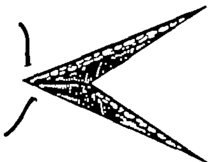


Fig 170
Stitching of V-shaped wound.

at the apex of the V would interfere with its blood supply Many varieties of stitch are used including the simple interrupted and the over and over continuous Where the skin edges tend to turn inwards the end-on mattress stitch is employed (see Fig 171) The finest scar follows the subcuticular stitch described by Halsted This stitch is passed first through the whole skin at one end of the wound, where it is fixed by a knot or by an artery forceps It is passed horizontally through the deep layers of the skin on each side in turn to emerge finally on the skin surface at the farther end of the wound, where it is again tied or clamped In deeper wounds where possible closure is accomplished without the use of buried catgut If however there is a dead space several deep catgut stitches are inserted or a figure-of-eight skin suture

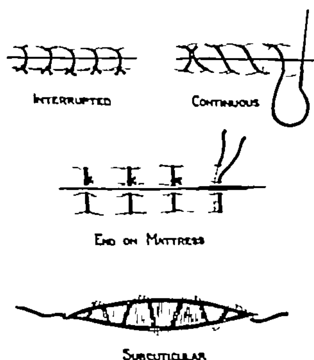


Fig 171
Varieties of stitch

Removal of Sutures.—Good lighting is essential Fine non toothed forceps and sharp pointed scissors are used It is wise to begin by removing only alternate sutures In the face this is done between the third and fifth post-operative days in other parts about the seventh day After removal of all sutures a dressing of gauze or wool soaked in collodion may be applied

Superficial Wounds with Skin Loss.—Where possible such wounds are covered with a free skin graft If the patient is not seen until twenty four hours or later after injury cultures of the surface are taken before grafting is decided on If the avulsed skin is available and is not damaged it is used as a whole thickness skin graft In flap wounds where the vitality of the flap is doubtful it should be detached completely (that is converted to a free whole thickness skin graft) and reapplied.

Deep Wounds with Skin Loss.—Two methods of repair are possible (1) secondary suture and (2) free skin grafts In wide defects, especially of the extremities the limb is immobilised in plaster of Paris and a window cut for dressing Once granulations have formed and are receptive a free skin graft is applied through the original window a wool pad inserted over the graft and a firm bandage applied over the wool and around the plaster The plaster is a useful device to obtain the necessary pressure on the graft

GRAFTING IN SPECIAL REGIONS

Eyelids—*Ectropion*—This is a relatively common result of deep burns of the face

Lower Lid—The scar tissue is infiltrated with novocaine to facilitate excision. An incision is made from canthus to canthus just outside the ciliary margin. The scar tissue is excised, care being taken to leave behind the orbicularis fibres and the eyelid margin brought into a slightly over corrected position. A pattern of the defect is cut in jaconette and traced on the retro-auricular skin of the same side. A dissected graft is removed and the secondary defect is closed directly with a subcuticular catgut stitch. The graft is applied to the eyelid defect and stitched with interrupted fine silk stitches some ends being left long to tie over a flavine wool pressure dressing. The first dressing is carried out seven days later

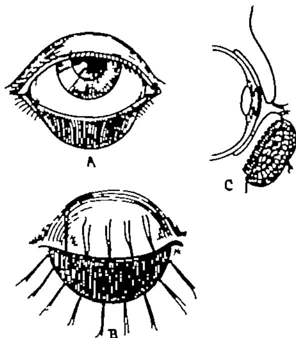


Fig. 172
Ectropion—lower lid.

Upper Lid—The scar tissue is infiltrated with novocaine and an incision made from canthus to canthus just outside the ciliary margin. The scar tissue is excised fibres of the orbicularis are left and interference with the levator is avoided. The eyelid margin is brought into an over corrected position. A thin stent mould of the defect is made and is covered with a razor graft taken from the inner side of the upper arm. The mould is applied to the defect and secured by mattress stitches. The first dressing is carried out seven days later

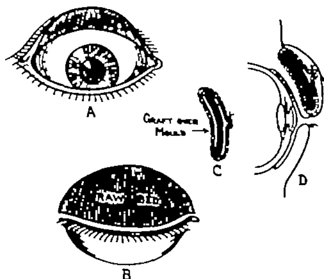


Fig. 173
Ectropion—upper lid.

Eye Socket.—After the loss of an eye the conjunctival fornices frequently become shallow and distorted by scar tissue. To restore the size of the socket and to allow the insertion of

an artificial eye the conjunctiva and scar tissue are excised and a razor graft is applied to a suitable size of disc mould which over distends the fornices The mould is inserted and held in position by the temporary approximation of the eyelid margins in the middle third (tarsorrhaphy) The mould is left in position for eight weeks if for any reason it has to be removed earlier it must be replaced immediately After the socket has been over-distended for eight weeks the mould is removed and an artificial eye inserted

Mouth.—The method of repair of defects in this region depends naturally on the tissues destroyed Where possible repair is carried out by local flaps details of which are too advanced for this short article

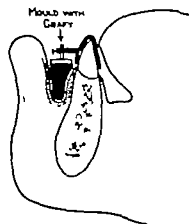


Fig 174
Buccal Inlay

Loss of Buccal Sulcus —If after infection or injury the buccal sulcus is obliterated and the fitting of a denture difficult or impossible all scar tissue must be excised and the lip and cheek freed from the jaw A mould of the defect is taken covered with a razor graft inserted and held in position by a tray on a metal cap splint made by a dental surgeon The mould is left in position for eight weeks thereafter a permanent prosthesis attached to a denture is worn.

Nose.—The detailed treatment of nasal defects does not come within the scope of this article Small losses of the skin of the nose are repaired by local flaps or by dissected grafts If the loss involves the nostrils a flap is required with an inner lining Rhinoplastic flaps are raised most often from one of three areas (1) the forehead (2) the pectoral region, or (3) the upper arm In most cases the lining is obtained by turning in skin flaps from the locality of the defect At the end of ten to fourteen days the pedicle is returned to its original site

Cheek.—The choice for repair lies between a flap and a free graft The vascularity of the tissues of the face makes rotation flaps both suitable and possible The incisions are made to fall in the natural lines of the face and the secondary defect placed where it will be least obvious and where there is lax skin for example below and behind the ear A rotation flap is always preferable to a free graft

Hand.—Loss of skin of the hand is a common sequel of injury *e.g* burns On the dorsum of the hand it may lead to hyperextension of the metacarpo-phalangeal joints with flexion at the interphalangeal joints on the palmar aspect to all degrees of flexion deformity Prevention of such deformities can best be achieved by absolute rest of the injured hand in the painful and infective period and by early excision of the burn

For skin loss alone replacement by a free skin graft will suffice on extensor surfaces a thick razor graft on the palmar aspect a full thickness graft For loss of skin and subcutaneous tissue direct or pedicle

flaps are employed Thereafter further procedures where necessary mobilisation of tendons division of ligaments capsulotomies nail traction amputation of fingers etc are carried out To improve the circulation of the hand, a preliminary sympathectomy may be advisable In the surgery of the hand hasty radical decisions must be avoided since improvement continues for a period of at least one year, provided finger exercises physiotherapy and constructive occupational therapy are employed.

A B W

CHAPTER XXIII

AFFECTIONS OF FACE, MOUTH, JAWS, AND *SALIVARY GLANDS*

CLEFT LIP AND CLEFT PALATE

THE surgical treatment of cleft lip and cleft palate has a threefold aim the restoration of structure the provision of a *functioning* palate and the correction of disfigurement In cleft lip the functional disability is least important though feeding may be *troublesome at first and* require the use of a large teat or covered spoon It is the disfigurement that calls most urgently for treatment and the parents are naturally concerned to have this corrected as soon as possible It is important that a satisfactory feeding routine be estab lished before operation and that the infant be in good condition gaining *weight steadily with an adequate hæmoglobin level If there be any* doubt on these matters a period of trained supervision in a convalescent home should be provided The age of choice then for repair of the lip is about three months

In cleft palate the functional disability is all important as both feeding and speech require an efficient nasopharyngeal mechanism Feeding is often troublesome demanding much patience and skill but as a rule these infants thrive well and there is no urgency for repair *because of feeding difficulties It is however extremely important* that a mobile palate of adequate length be provided before the child begins to talk otherwise faulty habits are acquired which it may be impossible to correct with speech training The age of choice then for repair of the cleft palate is about fifteen months It should be realised that good speech demands more than an efficient mechanism and that a good surgical repair may yield disappointing speech results in an unintelligent child with careless or unco-operative parents On the *other hand it is surprising how well some children speak whose* palates appear most imperfect It is sometimes difficult to determine whether defective speech is due to an incompetent nasopharyngeal sphincter or to the mental or psychological make up of the child observation and training by a speech therapist is essential in such cases The defect in the palate may be so extreme that little or no muscle tissue is present and however successful the repair may appear good function will not be possible

No special pre-operative treatment is called for but it is wise to have the child admitted to hospital for a few days before operation so that it may become accustomed to the nursing and feeding routine It

should be remembered that these children are subject to catarrh and mild infection of the nasopharynx and a careful examination should be made for the presence of infection of the middle ear antra, air sinuses tonsils and teeth and appropriate treatment carried out The anæsthetic of choice is Gas Oxygen Ether administered by the armoured endotracheal tube with some form of self retaining gag the mouth being packed with gauze In the more severe types of alveolar cleft both single and double the introduction of an endotracheal tube may prove difficult and in such cases the use of a modified Boyle Davis gag or of an intra nasal catheter or of an intra-oral flexible metal tube may be found more acceptable If breathing is difficult after the operation, a stout silk worm stitch should be passed through the tongue and kept in place for twenty four or forty-eight hours. For repair of the palate the surgeon is seated facing the end of the table with the child s head supported upon a lower head rest or upon the surgeon s knees For repair of the lip some surgeons prefer the child supine upon the table with the neck extended over a narrow sand pillow The surgeon sits facing the child as it is easier to assess the æsthetic result of the steps of the operation when facing the child in the normal way

There should never be any necessity for transfusion of blood or plasma unless for any reason operation has been delayed until the child is two or three years of age when the hæmorrhage is relatively greater than in infants The post-operative course is usually uneventful though a sharp rise of temperature to 103° or more is not uncommon in the first day or two It is remarkable how well the infants appear to bear the discomfort A sedative is rarely necessary but if required chloral hydrate in a palatable preparation is the safest It is well to apply light splints to the arms to prevent exploratory fingers from reaching the mouth No dressing is required for the lip the wound being gently cleansed with saline as required nor should any attempt be made to cleanse the palate other than by drinks of sterile water after each feed The stitches are removed about the tenth day, an anæsthetic usually being necessary Infection of the wound is almost unknown and the use of penicillin and of sulphonamides is perhaps an unnecessary precaution Failure of union is equally rare and must be regarded as a failure of technique

The history of the operative repair of cleft lip and palate proclaims the inadequacy of many of the former methods and to Victor Veau more than to any other belongs the credit for placing the operative technique on a firm basis Various modifications of his methods have been developed and the work of Denis Browne Dorrance Kilner Wardill Brown and McDowell and others has been followed by greatly improved results The defect varies greatly in form and extent and each case calls for an individual technique but there are a number of basic types of defect for the repair of which general principles may be stated (1) The cleft lip with intact alveolus—the pre alveolar cleft (2) the cleft of the soft and hard palate (3) the cleft alveolus and lip usually associated with a cleft of the palate (4) the bilateral cleft of the lip and of the palate with projecting pre-maxilla and poorly developed alveoli

1 **The Pre-alveolar Cleft of the Lip** —In incomplete cleft of the lip with little or no flaring of the nostril a simple V excision based on the operation described by Rose in 1891 will usually suffice (Fig 175) The tapered red margins are superfluous and must be excised and the exact amount of tissue to be sacrificed can be determined with tolerable accuracy The lower end of the normal philtral ridge is visible as a

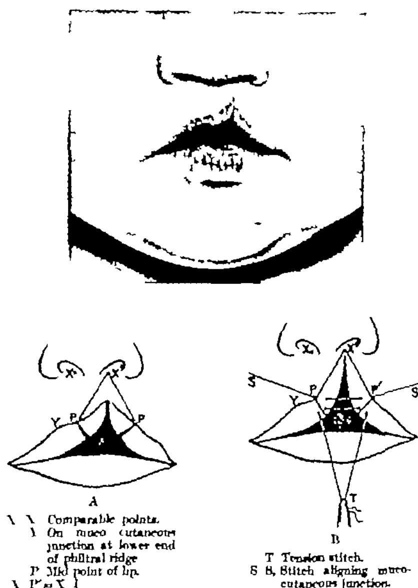
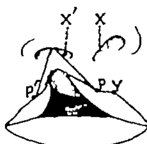


Fig. 175

The pre-alveolar cleft of the lip.

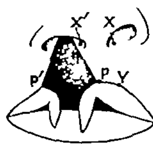
slight notch on the muco-cutaneous border and the mid point of the lip lies a little medial to this. At this point the red margin begins to taper and here the lip is transfixed and cut through at just over a right-angle to the free border The tapered red margin is excised and the incision carried just beyond the apex of the cleft The lateral border of the cleft is similarly excised the length of the incision being made equal to the medial one It will be found that the lower end of this lateral incision corresponds almost exactly to the point at which the





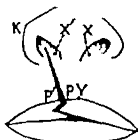
A

X, X′ Comparable points.
Y Lower end of philtral ridge.
P Mid point of lip.
X′ P′ = X P



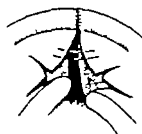
B

X, X′ Comparable points.
Y Lower end of philtral ridge
P, Mid point of lip.
X′ P′ = X′ Y = X P



C

Interdigitation at red margin.
K = Kink in alar curl which becomes a curve in seven to ten days after operation.



D

Relaxation slits in mucous membrane to allow flaring of margin.

Fig. 1 6

The pre-alveolar cleft of the lip.

lateral red margin begins to taper and the depth of the lip will equal that of the sound side The wound is made tense by traction on a stitch through the free margins and the muco-cutaneous junctions accurately aligned If there is any tendency for red margin to buckle a narrow wedge of it may be excised Fine catgut is used to approximate the muscle and evert the mucous membrane and the skin edges are sutured with gossamer silk worm gut or nylon

When the nostril is flared with excessive width of the floor the cleft has a wider entrance and the tapering of the red margin is more extensive (Fig 176) The width of the nostril floor is reduced to normal by carrying the apex of the incision within the vestibule and the edges of the incision there are undermined to allow restoration of the alar curl The excision of the borders of the cleft is carried out from the apex downwards until full depth of the lip has been attained. At this point the red margin

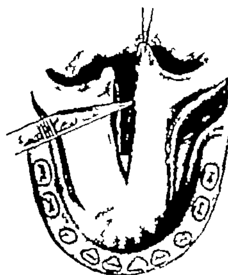




Fig 177 Fig. 178

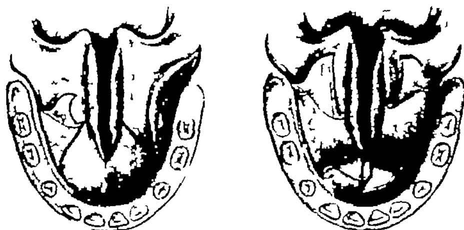
Figs. 177 and 178.—*Cleft of the soft and hard palate.*

may lack fullness owing to the more extensive tapering and some form of interdigitation of the red margin edges is required. Lastly the mucous membrane when sutured may be unduly tense and tend to invert the red margins Small relaxation cuts must then be made in the mucous membrane to lessen the tension and allow a slight outward flare of the lip

2 **Cleft of the Soft and Hard Palate** —It is generally stated that a cleft of the palate is always associated with congenital shortening and that operative treatment must therefore include backward displacement of the palate as well as repair of the cleft There are however, many cases of cleft of the soft palate only in which the shortening if any is negligible and repair of the cleft alone does provide an efficient functioning palate This type of operation is undoubtedly less severe than the displacement operation and a short description of it is therefore included here (Figs 177 and 178)

Two long relaxation incisions are made parallel with and close to

the alveolar ridge from the level of the lateral incisor tooth to just beyond the posterior end of the alveolus At this point the incision is deepened by blunt dissection to expose the pterygo-mandibular ligament and the hamular process which is broken through at its base and bent inwards to release tension of the tensor palati muscle The palatal aponeurosis is freed from the end of the alveolus and from the posterior border of the hard palate and the posterior palatine vessels displayed and gently stretched from the foramen The muco-periosteum is elevated from the hard palate and separated from the nasal mucosa at the apex of the cleft The nasal mucosa is elevated from the nasal surface of the hard palate and from the lateral wall of the nose If these steps are thoroughly carried out the edges of the cleft should lie together without tension The edges of the soft palate are split and the mucosal surfaces retract to allow ample raw surface for suture (Fig 178) The



Figs. 179 and 180.

Fig. 179 —Oblique incisions to produce four flaps. Posterior palatine vessels displayed.
Fig 180.—Flaps elevated. Nasal mucosa freed.

nasal mucosa is sutured with fine chromic catgut and the palate with through-and through mattress sutures of nylon everting the oral mucosa At the apex of the cleft the muco-periosteum is incised for a short distance and sutured with everting nylon sutures The wound before and after suture and the spaces left by the relaxation incisions are dusted with penicillin-sulphonamide powder

Many cases of apparent soft palate cleft have also a submucosal cleft of the hard palate In such cases and in open clefts repair of the cleft must be accompanied by the displacement of the palate backwards to ensure effective closure of the naso-pharyngeal *isthmus* Of the various forms of operation designed for this purpose the most widely used at present is that described by Wardill in 1937 in which the long muco-periosteal flaps employed by Veau are replaced by *four short* ones. The muco periosteum is divided into four flaps by oblique incisions which commence at the posterior edge of the hard palate and at the border of the cleft and run obliquely forwards and outwards to

join the lateral relaxation incisions just short of their anterior ends The two posterior flaps are displaced backwards with the palate and finally sutured in front to the anterior flaps The following description is of an operation based on Wardill s (Figs 179 to 182) The first steps are similar to those for repair of the cleft and at this stage the two halves of the palate should be relaxed and capable of meeting in the mid line without tension To allow backward displacement however three points of attachment have to be dealt with namely the muco-periosteum the posterior palatine vessels and the nasal mucosa The posterior palatine vessels are usually directed forwards with the palate and when they are adequately freed they can be swung backwards through an arc of 45° when the palate is displaced Wardill considers it essential that the vessels be cut and ligatured to allow satisfactory



Figs 181 and 182.

Fig. 181 —Nasal mucosa sutured. Soft palate suturing
Fig 182.—Four flaps sutured.

displacement and this may be done if they cannot be adequately mobilised (This deprives the palate of some of its blood supply and if it seems unduly pale the operation may be concluded at this point by suture of the cleft and displacement postponed for three months) The muco-periosteum is divided by the four flap technique of Wardill The remaining attachment is the nasal mucosa and this must be extensively freed from the lateral nasal wall to allow displacement of the mucosa backwards with the palate Furthermore it is highly desirable to shut off the nasal cavity by suturing the nasal mucosa in the mid line The mucosa however varies much in thickness and mobility and these objects cannot always be attained Small transverse cuts may be required to allow backwards displacement of the mucosa with the palate If the septum is well developed mucosal flaps may be raised from one or both sides and sutured to the lateral nasal flaps (Fig 183) With the freeing of these attachments the palate can be displaced backwards almost in contact with the posterior pharyngeal wall The

nasal mucosa is sutured with fine chromic catgut and the soft palate with through and through mattress sutures of nylon everting the oral mucosa These sutures are carried forwards to approximate the edges of the posterior muco-periosteal flaps which are medially rotated

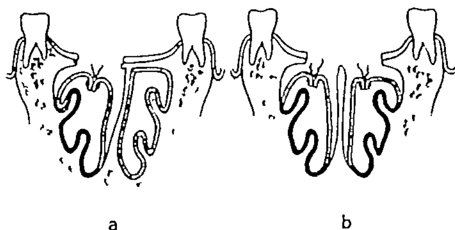


Fig 183
Mucosal flaps.

Their anterior ends are then sutured to the sides of the apex formed by the anterior flaps and the four flaps anchored to the underlying nasal mucosa

3 **The Cleft Alveolus with Cleft Lip and Palate** (Fig 184) —In the more severe types of this defect the edges of the cleft are staggered the



Fig. 184
The cleft alveolus with cleft lip and palate

lateral being poorly developed and depressed, and the medial projected forwards with marked deviation of the septum and nasal columella The alignment of the dental germs is inswept with the edge of the cleft and the eruption of the teeth in consequence faulty with in some cases complete absence of one or two teeth.

To achieve a satisfactory æsthetic result upon such a defective foundation is almost impossible in infancy but satisfactory moulding of the bone follows repair of the soft tissues and the final result often exceeds expectations It has been the practice of many surgeons following the procedure carried out by Veau to close the anterior palatal and alveolar clefts with mucosal and muco periosteal flaps as a first step and to repair the lip subsequently Where however the alveolar cleft is wide and the edges much staggered the subsequent moulding of the bone is not always satisfactory There is much to be said in favour of a primary repair of the lip as the moulding of the alveoli and eruption of the teeth can be more easily controlled By the time the palate is due for repair the width of the gap is much less and the closure can be carried out along with that of the palate Should closure of the alveolar gap prove troublesome the use of a dental prosthesis to close the gap and carry any missing teeth may prove eventually more satisfactory than surgery both from a functional and from an æsthetic point of view

A satisfactory repair of this type of defect demands a most careful technique and for exact details the reader is referred to the various articles in the literature The main steps may be outlined as follows —

The Alar Curl and Floor of the Nostril (Fig 185) —The buccal fornix is incised and the lip and cheek extensively freed from the underlying

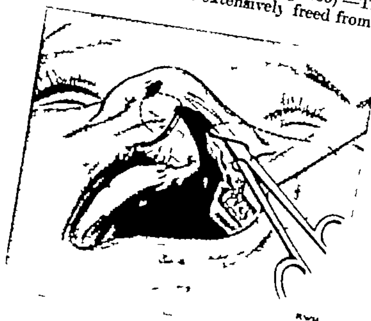


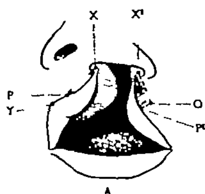
Fig. 185

Incision in buccal fornix carried upwards to free ala from inferior concha. Columella freed from displaced nasal spine. The dotted line indicates the extent of undermining from the underlying bone Small sharp scissors used to free the lining of the nostril and overlying skin.

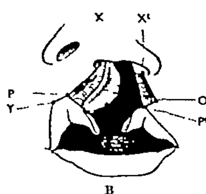
maxilla and the nostril from the lower edge of the inferior concha On the medial side the lip and columella are freed similarly from the underlying bone A satisfactory alar curl can be more easily attained by undercutting the mucous lining and skin of the nostril

Depth of Lip —If the angle of entrance of the cleft is very wide it will be found impossible to gain adequate depth of lip by a simple

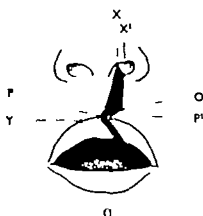




A



B



C

Fig 186

Method of repair for complete cleft. Shaded area excised.

Y Lower end of philtral ridge.

P Mid point of lip.

Y O P' = Y P

V excision without sacrificing too much red margin In such cases some form of angled incision or flap technique such as that of Mirault is necessary (Fig 186) The technique employed by Brown and McDowell

has proved satisfactory with minor modifications to suit individual cases

The Red Margin.—*The degree of tapering varies much and usually it* is necessary to employ marginal flaps to gain full thickness of the red margin

Flare of the Lip —*This characteristic feature of the baby lip is highly* important from an æsthetic point of view and a satisfactory flare well repays time and trouble spent Suture of the mucous membrane must be carefully watched and if there is any tension likely to tack down the lip this must be relieved by lateral cuts and if necessary undercutting of the mucous membrane

4 **Bilateral Cleft Lip and Palate** —The extent and form of this type of defect varies infinitely and the individual technique of repair must be adjusted accordingly but there are certain basic *problems common to* all the defects that call for comment (*a*) The premaxilla (*b*) the prolabium (*c*) the absence of a mucous membrane sulcus to the *prolabium* (*d*) *the columella*

(*a*) The degree of projection of the premaxilla appears exaggerated owing to the the poor *development of the alveoli* If the projection is moderate in degree repair of the lip can be carried out provided that the lateral elements are adequately freed from the maxillæ Not infrequently however the projection is so extreme that repair of the lip is obviously impracticable The former practice of reducing the projection completely by submucous resection of bone led to an unsightly flattening of the profile or faulty union with backward tilting or even complete non union and persistent mobile premaxilla A moderate degree of reduction may be obtained by removal of a small section of bone immediately behind the premaxilla at its junction with the heavy vomer keel the premaxilla being pinned or fixed with a dental plate This reduction should be sufficient to allow suture of the lip without undue tension To *secure symmetrical moulding of the bone it is wise to repair* both sides at the same time the technique being essentially the same as for the unilateral cleft

(*b*) The prolabium varies *greatly in size and form If it is of* reasonable size it can be used to form the entire philtrum the lateral elements of the lip being sutured to the sides only the tapered red margins being *interdigitated below* The tenous red margin of the sides of the prolabium are reflected as flaps and sutured to the mucous membrane of the lateral elements If the prolabium is extremely *small* part of the lateral elements must be used to provide depth for the central lip (Fig 187)

(c) The prolabium has usually no sulcus but it is wise to postpone the provision of one until the bone has moulded well and the eruption of the teeth is satisfactory A mobile lip is essential for good speech and a sulcus should therefore be provided by a simple plastic procedure before speech therapy is started

(*d*) The columella is usually of negligible proportions but develops considerably as the child grows If it is still small by the time the child reaches school age a V Y advancement type of operation can then be carried out

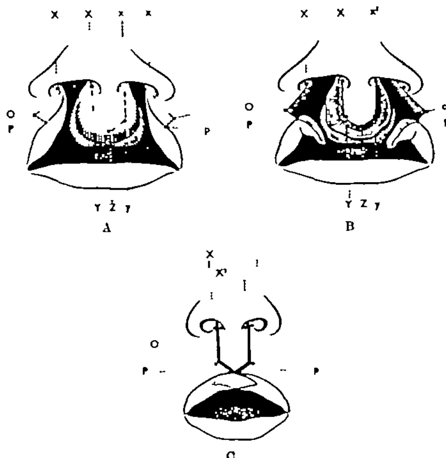


FIG 187

A method of repair for complete bilateral cleft. The perimeter if the prolabium is reflected as a flap for suture of the mucosal surfaces. P and *p* are points where the red margins begin to taper XOP correspond to XYZ and *xop* to *x yz*.

Repair and lengthening of the cleft palate are carried out at the usual age as already described. It is essential that the co-operation of the orthodontic specialist should be enlisted to control the alignment of the alveoli and the development of the palate

M W

REFERENCES

BLAIR, V P., and BROWN J B. (1930). *Surg Gynec. Obstet.*, 51, 80.
BROWN J B., and MCDOWELL, F (1945). "Simplified Design for Repair of Single Cleft Lips." *Surg Gynec. Obstet.*, 63, 12 26.
—— (1947). *Surg Gynec Obstet.*, 85, 20
BROWNE, DENIS (1932). "The Operation for Cleft Palate" *Brit J Surg.*, 20, 7
—— (1940). "Hare Lip." *Annals of Royal College of Surgeons England.*, vol. v No. 3.
DORRANCE, G M. (1933). "The Operative Story of Cleft Palate" W B. Saunders Company Philadelphia and London.

DORRANCE, G M and BRANSFIELD J W (1943) Cleft Palate *Ann Surg.*, 117 1.
—— (1947). *Surg Gynec Obstet.*, 84, 878
KILNER, T P (1937). *Speech* ii No. 3.
—— (1937). "St Thomas's Hospital Reports" (second series), ii.
LE MESURIER, A B. (1949) A Method of Cutting and Suturing the Lip in the Treatment of Complete Unilateral Clefts. *Plastic and Reconstructive Surgery* vol. iv No. 1
MOWLEM R. (1948). "British Surgical Practice Butterworth & Co., London vol. iv No. 49.
OLDFIELD M C (1949). "Modern Trends in Hare Lip and Cleft Palate Surgery with a Review of 500 Cases. *Brit J Surg.*, 37 178 194
OMBREDANNE, L. (1932). Chirurgie Infantile Masson et Cie Paris.
PASSAVANT GUSTAV (1860). *Virchow's Arch* 46.
ROSE, W (1891) "Hare Lip and Cleft Palate H K Lewis London.
VEAU VICTOR (1931) "Division Palatine Masson et Cie, Paris.
—— (1938). "Bec de Lièvre Masson et Cie Paris.
WALDRON C. W (1950) *Management of Unilateral Clefts of the Palate* *Plastic and Reconstructive Surgery* vol. v No. 4
WARDILL, W E. M (1937 38). "The Technique of Operation for Cleft Palate *Brit J Surg* 25, 117

FACIO-MAXILLARY INJURIES

Deformity of the face resulting from injury may cause serious social and economic disability and also have profound psychological consequences In the treatment of facial injuries it is therefore necessary not merely to obtain sound healing but to do so with the least possible disfigurement When the injury involves the jaws it is also necessary to secure accurate reduction of any displacement for faulty dental occlusion interferes greatly with mastication

The treatment of facio-maxillary injuries demands special training experience and equipment and should be carried out in close co-operation with the plastic surgeon and the specialist dental surgeon The advice of a neurosurgeon an ophthalmologist and a specialist in ear nose and throat work should also be available Whenever possible such cases should be sent to special facio maxillary units where there are facilities for satisfactory treatment

First Aid.—Because of the great vascularity of the face immediate hæmorrhage after injury may be severe It can almost always be controlled by direct pressure Ligature of the carotid vessels is very seldom necessary Shock is rarely severe when it occurs it is usually hæmorrhagic in type and is readily controlled by transfusions of blood or plasma

In severe injuries of the lower face with a comminuted mandibular fracture the immediate danger to life is asphyxia The tongue, deprived of its anterior attachment falls backwards and mechanically obstructs respiration A more gradual but none the less serious form of asphyxia is caused by blood and débris accumulating in the pharynx and being aspirated into the trachea and bronchi To prevent either of these tragedies occurring it is absolutely essential to *nurse every severe case of fractured mandible on his face until the time of operation* It is also advantageous to hold the tongue forwards by a suture or safety pin passed through the tip and fixed to the chest with adhesive

In less severe mandibular fractures where there is no danger of asphyxia considerable relief is obtained by splinting the mandible against the intact maxilla *The barrel bandage is an efficient method* of doing this but any form of bandaging or strapping which gives

upward support to the mandible will suffice There must be no backward pressure on the mandible—as with the commonly advocated four tail bandage—since this tends to obstruct respiration

Fractures of the maxilla require no first-aid treatment unless in the very rare case where the whole maxillary block is displaced downwards against the tongue so obstructing respiration In such a case it is necessary to support the maxillary block by means of a Kingsley splint This consists of a dental impression tray with side-arms issuing from the mouth which are fixed to a web or P O P headcap

Anæsthesia of Facio maxillary Injuries.—Local anæsthesia is adequate in dealing with small wounds of the face General anæsthesia is necessary when the wounds are large when they involve the mouth or nose or when there is liable to be bleeding into the mouth or nose The anæsthetic is administered via an endotracheal tube—oral or nasal as is more convenient—and the naso-pharynx is tightly packed with gauze soaked in liquid paraffin to prevent the inhalation of blood and débris

FRACTURES OF THE FACIAL BONES

I Mandible

The mandible may be fractured in any part the more common sites being in the regions of the canine tooth, the angle and the condylar neck. Any degree of comminution may occur depending on the severity of the violence As a rule fractures of the body of the mandible are compound into the mouth

Treatment is dependent not only on the site and severity of the bony damage but also on the number and state of the teeth on both jaws Each individual case therefore requires careful consideration by both surgeon and dental surgeon before treatment is decided on The aim of treatment must be accurate anatomical reposition of the fragments and their rigid fixation until clinical union occurs If even minor displacement of the fragments persists the correct dental occlusion may be altered and cause permanent disability

Good X rays are the first essential It is possible by suitably tilting and rotating the head to visualise any part of the lower jaw and the co-operation of the radiologist should be obtained in getting the proper views It is particularly important to find out if the fracture line passes through a tooth socket Such a tooth forms a potent source of infection, and should be removed. The possibility that the fracture may be bilateral must not be overlooked.

Reduction and fixation are best effected under general anæsthesia although in simple cases local anæsthesia may be adequate Unless in the case of fractures of the condylar region which will be dealt with separately reduction is easily carried out manually in early cases

Methods of Fixation.—Practically all methods of fixation at present in use employ the maxilla as a rigid splint the mandibular fragments being fixed to the maxilla with the teeth in proper occlusion The following pages give the more common methods

1 *When Teeth are Present on both Fragments*

(a) *Interdental Wiring* —This is the simplest, quickest, and most readily available method of obtaining fixation In its simplest form a length of stainless-steel wire is looped around the neck of a suitable tooth on the mandibular fragment and twisted tight A similar loop is made around an opposing tooth on the maxilla and the ends of the two loops twisted together so that the teeth are brought into firm occlusion Each mandibular fragment should be fixed by at least two such sets of ties if possible

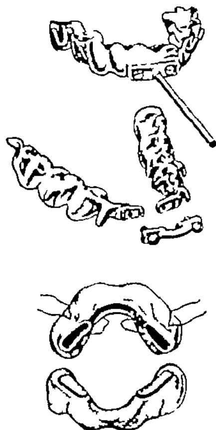


FIG 188

a Cap splints showing maxillary cap splint with external rod for fixation to plaster head cap.
b mandibular cap splints in sections with locking bar
c, Gunning s splints.

It is more usual to fix eyelets to opposing teeth and then join the eyelets by a strong tie wire By using eyelets, intermaxillary fixation can be removed and reapplied easily by cutting and replacing the tie wires This allows the fracture to be tested for clinical union When the teeth are scanty and irregular a stainless steel arch band wired to the teeth may be used Intermaxillary fixation is obtained by wires between the arches (Fig 189)

(b) *Cap Splints* —Cast in silver alloy from impressions of the patient s teeth, these fit accurately over the crowns of the teeth and are made sectionally one section to each mandibular fragment and one for the maxilla (Fig 188) They provide more rigid fixation than does interdental wiring but require the services of a dental mechanic and laboratory and necessitate a delay of twelve to twenty four hours before they are ready for application The splints are first cemented to the teeth and then by means of hooks, attached to the sides of the splints the mandibular fragments are wired to the maxilla in proper occlusion The sectional splints on the mandibular fragments are then fixed to each other by a specially made locking bar This bar can be unscrewed when necessary to allow the fracture to be tested for clinical union (Fig 190)

2 *When Teeth are Absent*

In the edentulous patient Gunning s splints are used (Fig 191) They are made in acrylic and resemble dentures without teeth If

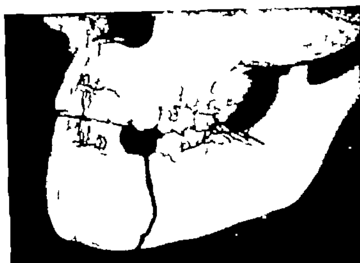


Fig. 189

Fixation of mandibular fractures

Interdental wiring Simple wire loops on the posterior teeth. Eyelet wires anteriorly Note that the teeth in the line of fracture have been extracted.

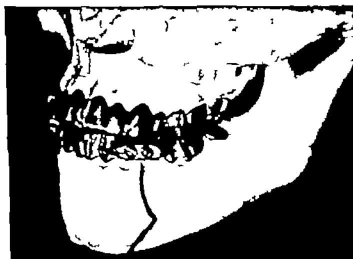


Fig 190

Fixation of mandibular fractures

Sectional cap splints applied. The mandibular sections have been fixed with a locking bar after reduction of the fracture and the whole then fixed to the maxillary section with wire loops.

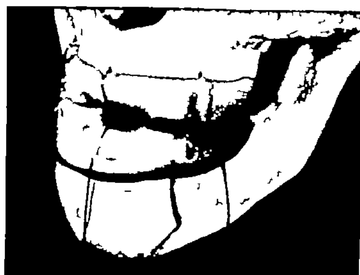


FIG. 191

Fixation of mandibular fractures.

Edentulous patient. Acrylic "Gunning's" splints wired in position. The lower has been lined with black gutta-percha to ensure a good fit. Note how the mandibular wires pass round the mandible while the maxillary wires are passed through small holes drilled in the alveolus.

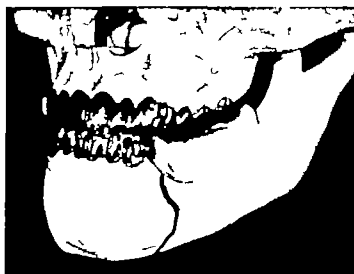


FIG. 192

Fixation of mandibular fractures.

One fragment edentulous. Fixation by cap splints and an *acrylic* "*saddle*" for edentulous fragment. This is only adequate when there is minimal displacement and little movement of the fragments. When there is much displacement or abnormal movement some form of accessory fixation, as shown in Figs. 193 and 194 is used



Fig. 193

Fixation of mandibular fractures.

Screw pins. These are inserted at a distance from the fracture and may be used even in the presence of mild infection. Note how they are inserted along the lower border to avoid the tooth roots.



Fig 194

Fixation of mandibular fractures.

Interosseous wire inserted after open reduction. This is only suitable for uninfected cases.

the patient's own dentures have escaped damage these are easily adapted to the purpose and form ideal splints The lower splint after being lined with gutta percha, is fixed to the mandible by steel wires passed circumferentially around the bone The upper, similarly lined is fixed to the maxilla by wires passing directly through the alveolus The two splints are then wired together It is usual to leave a gap in front of the splints for feeding purposes (Fig 101) In the edentulous patient there is not the same necessity for exact anatomical reduction Any slight deformity may be compensated for in the future dentures

When there is little or no displacement of the fragments wiring of the splints to mandible and maxilla is often unnecessary It is sufficient to wire the splints together place them in position and apply a firm chin bandage

3 *Accessory Methods of Fixation*

(a) *External Splinting*—When a mandibular fragment cannot be controlled by any of the above means the fracture may be stabilised by means of steel pins inserted into each fragment and fixed by a rigid connecting bar (Figs 103 and 103) This method is particularly suitable in cases of fracturing at the angle in order to stabilise the posterior fragment External fixation alone is not sufficient however to splint a mandible and intermaxillary fixation by wiring or cap splinting must be applied at the same time



Fig 103

Stainless steel pins used to stabilise an edentulous mandibular fragment

(b) *Interosseous Wiring*—The lower margin of the body of the mandible is practically subcutaneous and a useful aid in fixation is the insertion through a small incision of a wire ligature between the bone ends This should only be used however in the complete absence of infection (Fig 104)

Fractures of the Condyle—When the condylar neck is fractured there is often considerable displacement of the condylar head Treatment should be directed towards obtaining a functional false joint rather than accurate reposition of the fragments Intermaxillary fixation is applied for seven to ten days until all local swelling has disappeared Active exercises are then commenced, steps being taken to prevent deviation of the mandible to the affected side Complete function is usually obtained but in cases where pain and trismus persist it may be necessary to excise the condylar head.

Severely Comminuted Fractures—Especially when associated with a gunshot wound severe comminution presents certain special problems The small bony fragments many of them torn from their

attachments are very liable to become infected and form sequestra They should be retained only in the absence of infection when both skin and mucous membrane closure may be obtained and when there is no actual loss of bone Prophylactic drainage is advisable When the wound is dirty or infected when there is actual loss of bone or where closure is difficult to effect it is better to remove all loose fragments of bone and prepare the wound for a subsequent bone graft

Infection in Fractures of the Mandible.—Infection of the fracture from the mouth is common especially in cases where the fracture has been neglected Drainage of the fracture line in such cases should be provided through a small incision in the submandibular region The drain should be removed in forty-eight hours Late infection may arise from a tooth in the fracture line or a necrotic piece of bone Treatment is to remove the cause and drain the abscess

Post-operative Care—Patients with intermaxillary fixation should be fed frequently with liquid or semi-solid foods care being taken that an adequate nitrogen balance is maintained. When there is associated difficulty in swallowing food should be given through a small indwelling stomach tube inserted at operation and retained until swallowing is possible

At the same time the highest possible standard of mouth hygiene is maintained The mouth is thoroughly irrigated after each meal with sodium bicarbonate solution and the teeth are well scrubbed with a tooth brush If the mouth is very dirty or if there is a concomitant wound of the buccal mucosa, hydrogen peroxide or very weak Eusol may be used as irrigants

Clinical union in fractured mandibles occurs many weeks before there is radiological evidence of bony union It is usual to test the fracture for union in simple cases four weeks after injury by undoing the intermaxillary fixation If union is not complete this is replaced and further tests carried out at fortnightly intervals

Delayed and Non union of Fractures.—Mandibular fractures as a rule heal readily Delayed union is commonly the result of either infection or inadequate fixation and the remedy is obvious Non union is usually the result of loss of bone either at the initial injury or as the result of sequestration In such cases a considerable gap may exist between the bone ends and this is best filled with a bone graft

Grafting must be postponed until both external and intra-oral wounds are completely healed. Through a submandibular incision the gap is exposed and the bone ends cleaned and freshened, the greatest care being taken not to open into the mouth Should this happen the operation is postponed A block of cancellous bone is then cut from the ilium and carved to fit the defect It is then wired to the bone ends and the joints covered with small bone chips Fixation is achieved by any of the methods detailed above and the wound is closed without drainage Good results have also been achieved simply by packing the defect with cancellous bone chips which fuse together and establish continuity

Dislocation at Tempero-mandibular Joint.—The joint may be dislocated by a blow on the chin when the mouth is widely opened or in

ascending meningitis from involvement of the cribriform plate and tearing of the dura Prophylactic courses of penicillin and sulphadiazine should be administered and if manipulative treatment for reduction is carried out an intrathecal injection of 50 000 units of penicillin given Reduction should be carried out as soon as possible The tooth bearing fragment (or fragments) is reduced into proper occlusion and fixed by means of cap splinting and external rods to a P O P headcap The fractures of malar and nasal bones are treated as described below If after reduction there are any signs of dural tearing—persistent cerebro-spinal rhinorrhœa or anosmia—the question of operative repair of the dura should be discussed with the neuro-surgeon

Combined Fracture of Mandible and Maxilla.—When both mandible and maxilla are fractured cap splinting is essential The maxilla is first reduced and stabilised to a P O P headcap The mandibular fragments are then reduced and splinted to the maxilla as described above

III Malar Compound

The malar bone itself is strong but has three more delicate attachments one with the zygomatic process of the temporal one with the frontal and one with the maxilla In a typical fractured malar the malar itself is seldom broken One fracture line passes through the zygomatic arch there is a separation of the fronto malar synchondrosis and a third fracture line passes downwards from the infra orbital plate through the infra-orbital foramen into the antrum The malar itself is depressed inwards and rotated downwards

Although the facial depression is often masked by a black eye the bony deformity is usually palpable and the diagnosis may be confirmed by other signs There is commonly anæsthesia in the distribution of the infra-orbital nerve There may be interference with jaw movements Diplopia is not uncommon due either to comminution of the orbital floor or damage to the peri-orbital tissues An X ray will show the fracture lines and the presence of blood in the antrum on the affected side

Early bony reduction is essential as the fracture consolidates rapidly In most cases reduction is best effected by the temporal route A small incision is made within the hairline in the temporal fossa on the affected side and the temporal fascia incised A flat bladed instrument—Bristow's elevator is most satisfactory—is passed down between temporal fascia and muscle and slipped under the malar which is then elevated into position. As a rule there is a distinct click when reduction is complete and there is little tendency to redisplacement in simple cases

In severe cases with much comminution the fracture after reduction may be most unstable In such a case it is best stabilised by inserting a screw pin into the most prominent and thickest part of the bone and fixing the pin to a P O P headcap (Fig 198) In some cases an interosseous wire between the fracture ends is of value

When the orbital floor is comminuted and displaced downwards it is essential to replace it in normal position to prevent diplopia. This can only be done by opening the antrum by the Caldwell Luc approach and forcing the orbital floor upwards with tight packing. Ribbon gauze soaked in Whitehead's varnish or sulphonamide cream is the best packing agent. The packing is left *in situ* for two weeks.

IV Nasal Bones

Considerable soft tissue swelling may occur after fracture of the nasal bones and it is best to postpone treatment until this has subsided. Reduction is performed under general anaesthesia. When displacement is slight reduction may be effected by digital pressure only. In more severe cases it is necessary first to disimpact the fracture with forceps. Walsham's forceps, which has flattened blades meeting near the tip and separated proximally, is designed for the purpose. If this is not available long sinus forceps or a small bowel clamp may be used. The blades should be protected by rubber tubing. One blade of the forceps is inserted into the nose, the nasal bone is gripped and thoroughly loosened. If the septum is displaced this should be corrected at the same time with suitable forceps. The bones are then moulded into normal position and held in place by an external splint of P.O.P. or malleable metal. When great comminution has occurred, it may be necessary to transfix the bridge of the nose with a stainless steel wire fixed at both sides to a flat button to hold the bones in position.

Facial Wounds

The aim in treatment of all facial wounds should be primary closure with minimum scar tissue formation. Because of the great vascularity of the face and by the use of modern chemotherapeutic drugs primary closure may be safely undertaken up to two to three days after injury.

Clean-cut incised wounds should be carefully cleansed and sutured without excision. With contused and lacerated wounds, on the other hand, a careful excision should be carried out before suture. All damaged, non-viable or grossly contaminated tissue should be removed and the skin edges to be sutured should present a clean "square-cut" appearance to allow of accurate suturing.

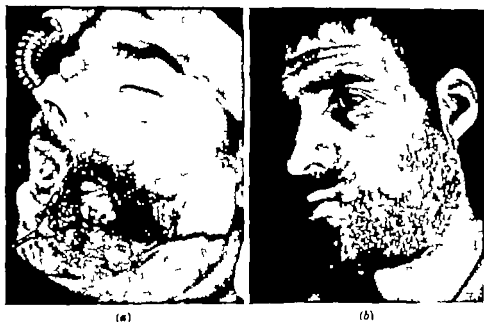
Suturing is best carried out with fine silk on small curved needles, preferably eyeless. The sutures should be inserted within 2 mm of the wound margin, and should take a deep bite of the sub dermal tissues. It is most important that two raw surfaces rather than two skin edges be brought into apposition in order that later depression of the scar may be prevented. The sutures are tied without tension and the most accurate apposition of the wound obtained. Multiple small sutures without tension are infinitely better than a few large tension sutures as the latter leave unsightly transverse scars.

The mucous membrane of the mouth is sutured with fine end-on

mattress stitches of silk, catgut is used only when difficulty might arise in removal Muscle and subcutaneous tissues are closed with the finest catgut

If a wound of the eyelids involves the conjunctiva no sutures should be inserted in the conjunctiva itself because of the danger of damage to the cornea With care however it is possible to pick up the extreme edge of the conjunctiva by a figure-of-eight skin stitch so that none of the stitch is in contact with the globe

The commonest cause of breakdown in facial wounds is hæmatoma formation in the wound track with later infection When there is any likelihood of this drainage should be provided by a small strip of thin rubber or several twisted strands of silkworm gut inserted through



(a) (b)

FIG 199

Direct closure of facial wound: (a) gunshot wound of cheek penetrating the mouth and fracturing the mandible (b) result five days after complete direct suture.

one end of the wound or—in the case of wounds of the lower face—through a small separate stab incision in the submandibular region.

Wounds with Soft Tissue Loss.—In most instances of lacerated wounds there is some degree of tissue loss When this is slight it is often possible to suture the wound directly but the greatest care must be taken that no deformity is produced The amount of loss which may be dealt with by direct suture varies considerably in different sites Thus on the lower eyelid a wound with a 1 to 2 mm loss of skin, if sutured directly may cause ectropion. On the other hand, a wound at right angles to the lower lip may be sutured even with a loss of 1 to 2 cm without producing deformity

Whenever there is any doubt it is better to test the effect of direct suture at the time of operation If deformity is produced, some other method of treatment must be adopted. The available methods in such cases of tissue loss are described on page 422

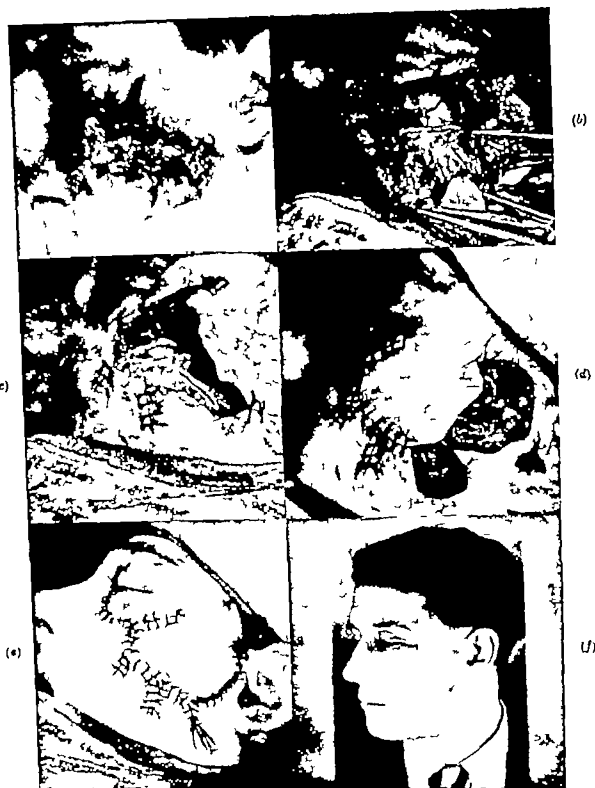


Fig 200

The rotation flap in primary closure of facial wounds (a) gunshot wound with tissue defect; (b) wound excised and opened up to show fracture of malar which has been wired (c) peripheral lacerations sutured and tissue loss defined; (d) rotation flap from in front of ear swung into defect; ( ) secondary defect closed by direct suture (f) result ten days later

(a) The wound may simply be débrided and left open Healing then occurs by granulation and scarring and repair is left until healing is complete Scar tissue, however is the greatest enemy of the plastic surgeon and every effort should be made to obtain primary closure or at least primary epithelialisation of the raw surface The only indications for leaving open a fresh facial wound are firstly that the loss is too great to allow of closure in one operation or secondly that the patient s general condition is too poor to allow the necessary operative *interference*

(b) The wound may be closed by means of local flaps of skin or rarely of mucous membrane The subject of local flaps is dealt with more fully in the chapter on Plastic Surgery and





Fig 201 Fig 202

Skin to mucous membrane closure.

Fig 201 —Three-day-old wound with much tissue loss.
Fig 202.—Result five days later after stitching skin to mucous membrane around the defect.

will not be considered in detail here The most useful type of flap is the rotation flap and a typical example is shown in Fig 200 Local flaps should only be used when it is possible to effect a complete repair at the primary operation No local flap should ever be cut which might interfere with *later reconstruction*

(c) Closure may be obtained by stitching skin to mucous membrane around the defect This applies particularly to wounds pene trating the mouth where there is considerable loss of skin muscle and mucous membrane (Figs 201 and 202) This allows primary healing to occur and the repair of the defect—which usually requires several operative procedures—is carried out later Skin to mucous membrane suture is also valuable *in full thickness* losses of nose and eyelids

(*d*) The raw surface may be covered with a split skin graft In cases which it is not possible to close by other means this provides a complete epithelial covering and thus minimises the amount of scar tissue formation, and simplifies the later repair No raw area should be left to heal by granulation which may be skin grafted at the original operation

Wounds of the Accessory Air Sinuses

1 *The Maxillary Antrum* —The antral walls may be damaged in fractures of the maxilla or fractures of the malar compound In such cases an X ray will reveal the affected antrum more opaque than its fellow from effusion of blood No immediate treatment is required The blood gradually absorbs in practically all cases If infection supervenes drainage should be established as described below

When there is gross comminution of the antral walls when a wound of the antrum communicates with the skin or with the oral cavity, or when a foreign body has become lodged in the antrum the antrum must be drained This is carried out by the Caldwell Luc approach through the canine fossa and sufficient bone should be removed at least to admit one finger All loose pieces of bone and necrotic mucosa are removed from the antrum It is preferable to perform at the same time an intranasal antrostomy as this greatly hastens the closure of the oral wound

2 *The Frontal Sinus* —Wounds of the forehead in the neighbourhood of the frontal sinus must be carefully explored for fractures in that region. Simple crack fractures are best left undisturbed unless X rays show similar damage to the posterior wall In such a case or when there is comminution or a depressed fracture of the anterior wall of the sinus the bone overlying the sinus should be removed sufficiently with nibbling forceps to allow exploration of the posterior wall If the posterior wall be fractured the bone must be removed piecemeal and any tears in the dura located and sutured Whether the posterior wall is fractured or not adequate drainage should be provided by means of a small rubber tube passed from the sinus into the nasal cavity before closing the wound

Wounds of the Pharynx and Larynx

Small penetrating wounds in these regions from small-arms fire are not uncommon in war surgery Treatment consists in toilet and suture of the external wounds and provision of dependent drainage to the track Tracheotomy is usually necessary because of reactionary swelling hæmorrhage or later sepsis Severe injuries with loss of tissue due to shells mortars or mines are occasionally seen but the immediate mortality from hæmorrhage or asphyxia is high An immediate tracheotomy is essential and later a gastrostomy is performed for feeding purposes Primary operative treatment consists simply in débriding the wound The repair of the defect is left till a later date

T G

TUMOURS OF THE FACIAL SKIN

Those most commonly met with comprise melanoma basal cell carcinoma (rodent ulcer) and squamous epithelioma

Melanoma may be benign or highly malignant The common congenital moles generally require no treatment unless they give rise to irritation ulcerate or bleed or unless other evidence of commencing malignancy appears

In such cases treatment is by excision Radiotherapy is not indicated for melanoma is not sensitive to radiation Care must be taken when a melanoma is excised that a sufficient zone of healthy tissue is removed This is important even though the melanoma is not malignant for inadequate removal is believed to add to the risk of malignant change When malignant change is suspected the excision should include a block dissection of the lymphatics and glands

Basal-cell carcinoma and *squamous epithelioma* react admirably to radiation which is usually the treatment of choice There can be no objection to excision of such lesions when it can be carried out radically without deformity but this will usually be difficult without more or less elaborate plastic procedures for many of these growths arise at awkward sites about the nose or eyes Such operations are only justifiable nowadays if radiotherapy is contraindicated by scarring for example The conservative nature of efficient radiotherapy therefore becomes of increased importance in this sphere and the results are good both from the curative and cosmetic points of view

Radium may be employed by implantation surface application or sometimes by the beam method according to circumstances while X rays are also largely used The well known radiosensitivity of rodent ulcers makes it possible in many cases to cut down the total dose so it may be administered more quickly either with radium or X rays By one X ray method (contact therapy) the whole treatment can be given in a few minutes in certain suitable cases

Even when the lesion affects the eyelids themselves it should be possible to avoid damage to the eye but in certain advanced cases where the distribution of tumour tissue makes it inevitable that the actual globe be subjected to considerable dosage complications notably in the form of cataract or glaucoma may be expected Enucleation of the eye may therefore be called for and in some instances may be a preliminary to irradiation

In the cases of squamous epithelioma the gland problem has to be tackled on the lines indicated elsewhere (see p 428)

CARCINOMA OF THE LIP MOUTH, AND TONGUE

Carcinoma in the region of the mouth may originate in the lip cheek, tongue floor of mouth or palate The treatment must be varied according to the situation of the growth and its biological type but the general principles are the same

Neoplasms in the mouth are *often of only moderate radiosensitivity* but operation is now no longer the method of choice and in the great

majority of cases the old formidable resections have given place to radiotherapy which at slight risk and with no mutilation achieves at least as satisfactory end results

Treatment of the Primary Growth

Provided that the services of an expert are available radiotherapy should be preferred for the treatment of the primary growth except in very early cases or where there are definite contraindications to its use

Radiotherapy is most successful in carcinoma of the lip for with so obvious a lesion the patient is likely to present himself for treatment at an early stage Excellent results are to be expected in the floor of mouth fauces and palate but the cheek and tonsil occasionally provide examples of well-differentiated growths which tend to be radio-resistant In the tongue all gradations are met with from the rather resistant lesions typically seen in the anterior third to the more ana plastic ones generally associated with the posterior zone The latter naturally respond readily to treatment but tend to metastasise more rapidly

Except for the more anaplastic types of tumour radium when available is more often used than X rays Using cavitary or implanted radium the necessary dose can usually be safely delivered in only seven to ten days and at the same time higher doses than by other methods can be administered without risk to the comparatively small volumes of tissues involved this fact is of some importance in dealing with localised but radio resistant lesions External radiation of the mouth and neck generally demands protraction of the treatment over some weeks It will be seen that the biological type of neoplasm present must influence the choice of method and while this can often be assessed clinically biopsy may have a place both in guiding the treat ment and weighing up the prognosis

Radiotherapy is contraindicated when the disease is beyond a stage when healing or palliation can be expected or if the patient is in very poor condition local contraindications include scarring from previous operation specific infection or irradiation and involvement of bone

Carcinoma of Lip—X ray and radium are both used in treatment Radium is commonly employed by the interstitial method or on moulds and the dose adjusted so that the whole thickness of the lip receives adequate radiation. Implantation is usually carried out after local in filtration anæsthesia and the needles are stitched in so as to remain in the appropriate arrangement every care being taken to avoid sepsis Delivery of an adequate dose by either method will take seven to ten days but while the needles remain constantly in position, moulds need only be worn for a number of hours daily X rays sometimes from a contact therapy apparatus are occasionally used often with two opposing fields so as to ensure satisfactory dose distribution

Operative removal of carcinoma of the lip should be carried out under intratracheal anæsthesia except for a small early growth in a bad risk case when local anæsthesia may be practicable

If the growth is small a V-shaped portion of the lip is removed Bleeding is controlled temporarily by digital compression at either end of the lip When the affected portion has been removed and the vessels have been ligated the sides of the V gap are drawn together with silk worm and catgut sutures



FIG 203
Carcinoma of cheek treated by radium implants. Five needles inserted at the *lateral part of the cheek pass horizontally* deep to the growth. One inserted near the upper lip passes vertically on the medial side to complete the barrage. A surface plaque was used also in this case.

If the growth is larger a rectangular block of tissue is removed including the full thickness of the lip down to its attachment to the al veolus This may involve the sacrifice of the greater part of the lip and to minimise the resulting deformity an extensive plastic repair is necessary of which the following are the main principles Incisions are carried downwards and laterally from the lower angles of the rectangular defect through the skin and soft tissues of the base of the lip and short incisions are carried laterally from the angles of the mouth In this way two flaps are formed which can be drawn together and sutured in the midline to form a lower lip of normal length In making the in cisions laterally from the angle of the mouth the mucous membrane is divided at a higher level than the skin so that it can be turned forwards to form a new red margin The elongation of the upper lip caused by the lateral incisions is corrected by removing V-shaped portions of skin at either end



FIG 204
Apparatus for surface application of radium (temporarily applied for photograph). Note arrangement of needles, faintly seen through wax, to produce uniform radiation at skin.

Carcinoma of Cheek.—A good deal of local infiltration is frequently en countered in such cases and im plantation of radium will rarely prove adequate Accurate and effective dosage throughout the cheek can usually be achieved by radium ap paratus by combining cavitary and surface methods In more extensive cases it may be necessary to use ex ternal radiation either with X rays or from a radium beam unit

Operative treatment should be restricted to cases unsuitable for radiotherapy It is carried out by a block dissection suited to the individual case

Carcinoma of the Tongue.—The variations in biological type of lesion met with here have already been indicated Careful palpation should always form part of any clinical investigation since especially posteriorly lesions may have infiltrated to a much greater extent than surface ulceration of the tumour indicates

According to the principles laid down treatment will be by implantation of radium needles in the tongue, followed by dissection of the neck, or by external radiation dealing with the glands and primary lesion at one time

Implantation of radium is best carried out under intratracheal anæsthesia though intravenous pentothal may be used in easy cases The needles are best stitched in position and the threads then brought out at the angle of the mouth for suitable external anchorage Acriflavine mouth washes, 1 1,000 are most effective in keeping the mouth clean and a fluid diet can be administered by a feeding cup during the period of treatment

Operative removal of carcinoma of the tongue is carried out under intratracheal anæsthesia The pharynx is packed with gauze to prevent aspiration of blood into the larynx. The tongue is drawn forwards by means of a silkworm suture passed through its anterior part on the side away from the growth A gag is inserted The cheek is held back by means of a retractor

If the growth is unilateral, the tongue is first split in the median plane to a point behind the tumour the division being made exactly in the median raphe to avoid hæmorrhage The mucous membrane is then divided at its reflection from the tongue to the floor of the mouth on the affected side and the dissection deepened between the muscles of the tongue medially and those of the floor of the mouth laterally At this stage the lingual artery or its branches are identified and ligated Lastly the affected side of the tongue is divided transversely behind the tumour and removed The raw surface left behind is smaller than might be supposed, and much of it may be covered by suturing the mucosa on the dorsum of the remaining half of the tongue to the mucosa of the floor of the mouth.

If the growth is in the midline, the operative treatment must be modified to permit the removal of the whole of the anterior half of the tongue. The mucous membrane of the floor of the mouth is divided the tongue is retracted forcibly to each side in succession to enable the genioglossus and hyoglossus muscles to be divided, and the intrinsic muscles are then cut through at a point behind the tumour

Carcinoma of the Floor of the Mouth.—Even when these lesions have spread to the alveolar margin (on which primary lesions may also originate) or to the tongue they usually respond well to radiation The quickest and most satisfactory method is by the use of radium on some dental apparatus such as can readily be contrived in a radiotherapeutic department generally combined with surface radium to ensure reasonably uniform dosage throughout the affected block of tissue External radiation might be called for in some of the more extensive cases.

Operative treatment must be planned according to the size and

situation of the growth and consists of a block dissection which commonly includes the affected mucous membrane the lingual salivary gland and the adjacent part of the tongue In some cases a portion of the alveolar process of the mandible must be removed too

Carcinoma of the Palate —Those lesions readily respond if treated by radium embodied in a simple dental applicator but great care should be taken to ensure that one is not dealing with a carcinoma of maxillary antrum which is beginning to involve the mouth The response of tumours arising in salivary rests in this region is often less satisfactory

Treatment of the Glands

Treatment of the primary growth and the glands must always be considered together and a definite plan decided upon at the start In some cases the cervical glands may be treated by radiotherapy at the same time as the primary growth using beam therapy for both regions or a combination of radium therapy and X ray therapy This line of treatment is indicated especially if microscopic examination or clinical judgment indicates that the growth is of anaplastic type and therefore presumably radiosensitive

As commonly however the treatment of the lymphatic zone must be by operation whether the primary growth is excised or irradiated The operation takes the form of a block dissection of the contents of the submental digastric and carotid triangles sometimes with removal also of the sternomastoid muscle and the internal jugular vein

If the glands in any one of these regions are palpably enlarged the indication for operation is clear The operation should be performed two or three weeks after the primary growth has been removed or after radiotherapy of the primary growth as soon as the reaction has faded and the response can be judged In early cases however with no palpable glandular enlargement the problem is more difficult The customary recommendation is that block dissection of the glands should be carried out as a routine even in the earliest case but it seems wiser to judge each case on its merits It is established that carcinoma of the lip is slow to metastasise and if the patient is elderly or in poor health it is often safe to temporise with the proviso that the patient must be kept under observation and subjected to operation at the first sign of glandular enlargement

In carcinoma of the tongue on the other hand lymphatic dissemination tends to occur somewhat more rapidly so treatment of the glands either by radiotherapy or operation should as a rule be carried out even though no gland is palpable Even here however in old or bad risk cases delay can often be justified In advanced stages of glandular involvement where the growth infiltrates the periglandular soft tissues a good response to radiotherapy is unlikely and only with very radiosensitive lesions is some palliative effect to be expected

The operation for malignant cervical glands is carried out under intratracheal anaesthesia Two standard procedures are described In Butlin s operation the contents of the submental digastric and carotid triangles are cleared out, in the operation associated with the name of Crile a more radical block resection is performed

A curved incision extends from the mastoid process below the angle of the jaw and up to the point of the chin while a short straight incision passes from its midpoint downwards and backwards towards the clavicle When the skin flaps have been elevated the boundaries of the submental and digastric triangles are identified and their contents dissected up and removed including all fat and fascia, the lymph glands and the submaxillary salivary gland. In the conservative operation the sternomastoid muscle is then retracted to gain access to the carotid triangle whence all glands and connective tissues including the carotid sheath are ablated In the radical operation the sternomastoid muscle and internal jugular vein are divided close above the clavicle and the whole block of tissue including the deep fascia, fat and connective tissues of the carotid and posterior triangles are dissected upwards Finally the muscle and veins are divided close below the mastoid process and the whole mass is removed

C F W I

DISEASES OF THE SALIVARY GLANDS

Suppurative Parotitis.—This bacterial infection is commonest in debilitated subjects after abdominal operations or in the course of prolonged febrile illnesses The most important predisposing cause is an uncleanly condition of the mouth and a diminished flow of saliva and prophylaxis must be directed towards eliminating these factors by the use of mouth washes and by regular cleansing of the tongue teeth and gums

When the development of parotitis is suspected penicillin should be given intramuscularly It may abort the infection. If suppuration develops the abscess should be opened and drained General anæsthesia is required The incision is made over the most tense and prominent part of the swelling usually near the angle of the mandible The incision is made parallel to the line of the branches of the facial nerve and is deepened only enough to divide the deep fascia A sinus forceps is then thrust deeply into the abscess and opened widely to give free drainage

Salivary Calculi.—Calculi usually develop within the main ducts of a salivary gland less often within the gland itself. The submaxillary gland is affected at least four times more frequently than the parotid

In many instances the calculus can be detected by bi-digital palpation through the mucous membrane of the floor of the mouth but if it is small or placed far back in the duct it can be recognised only in an X ray film

Removal of the stone is simple if it is of moderate size and situated well forward in the duct but it is a more difficult problem when the stone is far back or in the salivary gland itself The mucous membrane overlying the stone is anæsthetised by novocaine injection, and a small incision is made on to the stone in order to slit the duct The stone usually drops into the wound but if the surrounding tissues are indurated a scoop may be required for its extraction. It is an advantage at operation to employ a curved suction tube for the disposal of saliva

If the stone is small its discovery may be facilitated if an exploring probe is passed along the duct

If the stone cannot be removed or if there is much superadded infection, it will in the case of the submaxillary gland, be better to remove the entire gland from the neck. Approach is obtained through an oblique incision in a skin crease below the margin of the mandible. The incision traverses the platysma and exposes the posterior part of the mylohyoid the bellies of the digastric muscle and the posterior part of the gland lying on the surface of the hyoglossus muscle The gland is delivered by gripping it with forceps, and the external maxillary artery on its deep aspect should be isolated and preserved. On the deep aspect too are the hypoglossal and lingual nerves which are easily identified and are unlikely to be injured The submaxillary salivary duct is ligatured and the gland removed.



FIG 205
Submaxillary salivary gland, showing site for incision.

Salivary Fistula.—An external fistula in any part of the body is a source of continued misery to the victim, and a salivary fistula is no exception, as it entails the constant dribbling of saliva accentuated as it is at meal times

A fistula is almost always the outcome of injury It may occur in connection with the parotid gland or more commonly its duct A fistula of the gland itself tends to heal naturally especially if any under lying infective element is corrected. If it proves obstinate a brief period of irradiation by X ray or radium will bring about healing

When, as is usual the fistula arises in connection with the parotid duct repair is very difficult especially if the fistula emerges from the proximal or masseteric part Reconstitution of the duct is practically impossible on account of its small calibre and the shrinkage of the distal portion so that in the past various plastic methods have usually been attempted It cannot be claimed that they are successful indeed failure is so common that it is better to treat the fistula at the fountain head by suppressing the flow of saliva This can be done by deep X ray therapy as the salivary gland is very radiosensitive The activity of the gland on a diminished scale may be resumed within six months but meantime the fistula usually closes

Tumours of the Salivary Glands.—The surgical treatment of tumours of the salivary glands should be founded on an accurate appreciation of their pathological characteristics The common tumour is the so called mixed tumour which affects the parotid gland, and very seldom the other salivary glands. It is a simple tumour with occasional habits of behaviour which call for special consideration when surgical treatment is contemplated.

The tumour occurs in adults usually after the age of thirty years It develops slowly and increases in size very gradually—although there are exceptions to this rule Spontaneous malignant change formerly dreaded is now known to be exceptionally rare but recurrence of the tumour after operation takes place in about 20 per cent of instances The tendency to recurrence is probably accounted for by the lack of complete encapsulation in many tumours and the presence of clumps of cells remote from but continuous with the parent tumour

The aim of surgery in dealing with mixed tumours is to rid the patient of a disfiguring swelling An elderly patient will seldom seek treatment indeed will often refuse it In the past the surgical treatment has consisted of simple enucleation of the tumour from within its capsule but experience suggests that this simple manœuvre is associated with a high rate of recurrence and that the new tumour may grow more rapidly than the original Therefore the present practice is to supplement surgical removal by irradiation by either buried radium needles or an external application of X rays or radium Follow up of cases treated on these lines suggests that the combination of surgery and irradiation has fulfilled the expectation of preventing or delaying such recurrence

It has been recommended that removal of a parotid tumour be carried out on more radical lines and that a considerable portion of the gland itself should be included in the resection (parotidectomy) As with few exceptions the tumour is simple and remains simple and as the results of conservative treatment are satisfactory the practice has not been generally adopted

The removal of a parotid tumour calls for delicacy of dissection if the branches of the facial nerve are to be spared The skin incision should be made in the axis of the branches of the facial nerve related to the site of the tumour Hæmostasis should be very thorough to secure a dry field for dissection. An attempt should be made to shell out the tumour from within the fine areolar tissue which demarcates it from the surrounding glandular tissue It is usually successful but in a soft tumour rupture of the capsule may prevent a clean separation Some operators aim at removing a fringe of gland tissue along with the tumour but much more bleeding then occurs and the branches of the facial nerve are more likely to be injured

In very large tumours and especially if infiltration has occurred it may be necessary to remove deliberately a part of the parotid gland The resulting facial paralysis will have to be accepted it can at a later date be partly corrected by a plastic operation such as described on p 126

Tumours of the parotid gland which are obviously malignant present a difficult problem in treatment Very often the ramifications of the tumour preclude excision and only radiotherapy is available The radiosensitivity of the tumours varies greatly but at times they do not react satisfactorily and the ultimate result is poor B M D

REFERENCE

Bailey Hamilton (1947). Parotidectomy" *Brit med. J.*, 1, 404.

CHAPTER XXIV

AFFECTIONS OF THE NECK

BRANCHIAL CYST AND FISTULA

BRANCHIAL CYST—*A branchial cyst is almost always situated* in the carotid triangle superficial to the main vessels It should be approached through an oblique incision in one of the lines of skin cleavage The deep fascia is divided, and the anterior border of the sternomastoid is retracted backwards to expose the cyst The cyst is encapsulated and free from attachment to neighbouring tissues and can generally be enucleated with ease Occasionally as a result of recurring inflammation it is attached by dense adhesions to the internal jugular vein which thus may be endangered After removal of the cyst the deep fascia should be closed by two or three catgut sutures The skin edges *should preferably be approximated by* clips or a subcuticular suture



FIG 206
Excision of branchial sinus.

Branchial Sinus.—The small external opening of the sinus lies on the anterior border of the sternomastoid muscle a short distance above the sternoclavicular joint and opens into the wider end of a trumpet-shaped cavity derived from the cervical sinus. Followed upwards it sinks through the deep fascia and crosses the internal jugular vein in the middle third of the neck narrowing as it goes to give place to a narrow track, the remnant of the second branchial cleft This track, which *is about the* thickness of a slate pencil then turns deeply through the angle formed by the bifurcation of the common carotid artery and approaches the pharynx between the stylohyoid and stylopharyngeus muscles. It ends blindly as a rule in contact with the pharyngeal mucosa at the supratonsillar fossa

The whole track is surrounded by a sheath of loose areolar and lymphatic tissue which renders removal relatively easy unless repeated attacks of inflammation have caused the formation of fibrous adhesions

A transverse elliptical incision is made about 3 cm in length, to include the external aperture of the sinus This is deepened sufficiently to free the track some distance upwards A second incision obliquely

placed in the line of a skin fold, is made at the level of the upper border of the thyroid cartilage in order to give access to the upper part of the sinus

The sinus is followed upwards with ease until it turns deeply between the great vessels Gentle traction on the sinus combined with careful blunt dissection will generally result in the blind extremity coming away complete from the pharyngeal wall

In cases where an aperture exists into the pharynx it has been advised that the deeper part of the track be inverted into the pharynx by a probe passed along it This measure is however seldom called for

CERVICAL RIB

A cervical rib may displace the lowest cord of the brachial plexus and cause motor sensory or vascular disturbance of the upper extremity In some cases the symptoms are believed to result from pressure by the scalenus anterior muscle If the plexus is post fixed a normally placed first thoracic rib may exert similar effects

The symptoms often develop after a debilitating illness when the normal muscular support of the shoulder girdle is weakened. Early cases may be relieved by a period of rest in bed followed by the use of a sling to support the elbow and relieve the drag of the arm. Exercises designed to increase the efficiency of the weakened muscles should also be carried out.

In the more persistent and progressive cases operative treatment becomes necessary It may take the form of excision of the offending rib or division of the scalenus anterior muscle at its insertion

The patient is placed with the head slightly extended and turned towards the opposite side An angled incision is made with one limb parallel to and above the clavicle and the other placed along the lower 2 in. of the anterior border of the trapezius muscle

A flap of skin and platysma muscle is raised, the descending branches of the cervical plexus being divided, and the deep fascia of the neck is then laid open.

The omohyoid muscle is retracted upwards and the sternomastoid forwards exposing the brachial plexus and the scalenus anterior muscle The transverse cervical vessels may require to be divided.

Should simple scaleniotomy be considered sufficient the phrenic nerve is dissected free from the surface of the scalenus anterior which it crosses in a downward and medial direction, and preserved The musculotendinous fibres of insertion of the muscle are then divided piecemeal with blunt-pointed scissors

Should it be deemed necessary to remove the rib the brachial plexus must be freed and retracted gently downwards especial care being taken to avoid injury to the long thoracic nerve (of Bell) The posterior end of the rib is then exposed by dividing the scalenus medius at its insertion into the rib and dissecting off the attachment of Sibson s fascia on its medial edge and the intercostal muscles below The rib is now divided, along with its periosteum at its neck From this point it can be cleared and separated forwards and excised.

STERNOMASTOID TUMOUR

This is an oval swelling which appears within a week or ten days of birth and involves either the sternal or clavicular heads of the sternomastoid muscle

The tumour consists of a mass of young scar tissue and it is evident that attempts to treat it by massage or stretching are useless and may even increase the ultimate fibrosis It should therefore not be interfered with The swelling disappears spontaneously in four to six months.

In the early stages the swelling is tender and the infant assumes a position of wry neck in order to relax the affected muscle This temporary torticollis must be differentiated from a true myogenic torticollis which occasionally develops as the tumour shrinks and which requires operative interference

TORTICOLLIS

Operative treatment is not necessary for acute wry neck and is generally ineffective in spasmodic wry neck. In the congenital type operative treatment is valuable and should not be delayed

This type was formerly regarded as due to contracture of the sternomastoid muscle consequent on a birth injury The present-day tendency on the other hand is to attribute it to a developmental aplasia in which not only the sternomastoid muscle but other soft tissues are involved Consequently while in the first place attention must be directed mainly to the sternomastoid which is the most obviously contracted tissue it should not be assumed that this alone will suffice and particular care must be given to after treatment aimed at preventing contracture of the other affected tissues

In mild cases especially when the sternal head of the sternomastoid is alone involved subcutaneous division of the shortened muscle will suffice Under general anæsthesia a fine tenotome is introduced through a small puncture immediately above the clavicle To avoid the risk of damage to deeper structures the skin should be drawn downwards while the incision is made on to the clavicle and then allowed to retract up wards The tenotome is inserted transversely immediately deep to the skin and turned so that its cutting edge is directed deeply The muscle is then rendered taut by flexing and rotating the head and the con tracted fibres are divided due regard being paid to the safety of the internal jugular vein which lies beneath the muscle

In the more severe cases open division of the muscle is indicated and in most instances it is advisable to excise from ½ to 1 in of its lower extremity

With the neck extended and the head turned to the opposite side a transverse incision is made just above the clavicle over the lower end of the sternomastoid muscle The platysma muscle is divided to expose the sternal and clavicular heads The anterior and posterior margins of the sternomastoid are freed by nicking the deep investing layer of cervical fascia where it splits to enclose the muscle and a flat director is slipped beneath the muscle to protect the underlying carotid sheath

The sternomastoid is then completely divided The upper cut end is drawn downwards and the muscle freed sufficiently to allow of about 1 in. being removed

After securing hæmostasis the platysma and skin are sutured, a small rubber dam drain being left in the posterior angle of the wound for twenty four hours to prevent the formation of a hæmatoma

In adolescents and adults where the deformity has been of long standing shortened bands of prevertebral fascia also may require division

After-treatment—Where the operation has been carried out in childhood soon after the appearance of the deformity no immediate after treatment is necessary but a careful watch should be kept and if the deformity tends to persist or recur the treatment noted below should be adopted In older children it is advisable to give a course of exercises to correct the habit of carrying the head in the oblique position A poroplastic collar may be worn on the affected side from the mastoid process to the root of the neck fitting tightly so as to correct any residual deformity

Neglected cases in adolescents require fixation in the overcorrected position in plaster for two months as secondary ligamentous and bony deformities cannot be expected to yield to simple division of the sterno mastoid muscle It should be realised that the marked facial asymmetry which frequently accompanies wry neck will only regress to within normal limits after several years of growth following operation

In adults in view of the fixed bony deformity no treatment is effective

CUT-THROAT

In the first-aid treatment of cut-throat the immediate need is to arrest hæmorrhage In suicidal cut-throat since the head is usually held back while the wound is inflicted, the great vessels lie deeply protected by the sternomastoid muscles and generally escape injury The bleeding is mainly from superficial veins—the anterior jugular veins and their tributaries—and though profuse it can generally be arrested by firm digital pressure

The next indication is to relieve urgent dyspnœa Where the wound is above the thyroid cartilage relief may be gained by hooking the tongue forwards Where the wound is lower and opens into the larynx, the dyspnœa usually is reflex in character and soon subsides if suffocation seems imminent a laryngotomy tube should be inserted or an emergency tracheotomy performed.

When the patient has been moved into hospital more thorough treatment can be carried out General anæsthesia is sometimes preferred though usually no anæsthesia is necessary After the wound has been cleansed and bleeding points caught and ligated, the extent of the damage is defined. Generally it is less than appears likely at first sight.

If the larynx has been opened it is always advisable to perform tracheotomy the tube being retained in position for a few days until all danger of laryngeal œdema has passed

If the pharynx or œsophagus has been opened it should be repaired by catgut sutures In such cases the superficial wound should be packed open, or sutured lightly with ample drainage to guard against the danger of spreading cellulitis and subsequent mediastinitis Rarely where there is an extensive wound of the pharynx a temporary gastrostomy should be performed.

Apart from wounds involving the pharynx or œsophagus, the risk of sepsis is slight The main danger arises from pulmonary complications due to aspiration of blood immediately after the injury Accordingly the patient should be nursed in the sitting position and encouraged to cough Sedatives should be administered only in so far as they are necessary to control restlessness Sulphanilamide may be given

Throughout treatment the patient must be kept under strict supervision to prevent further attempts at suicide

CELLULITIS OF THE NECK

Cellulitis of the neck is a dangerous condition for the infection tends to spread widely under the deep fascia infiltrates the connective tissues round the carotid sheath and may gravitate to the mediastinum Œdema of the glottis is apt to occur and may cause sudden asphyxia

The treatment in the early stages is the same as for infections elsewhere The patient must be kept at rest in bed on a fluid diet Hot fomentations are applied to the neck Penicillin should be administered and treatment by sulphonamides is also sometimes advisable As soon as there is evidence of abscess formation one or more incisions should be made over the most prominent part of the swelling The instruments for tracheotomy should be kept ready sterilised at the bedside until the danger of œdema of the glottis is past



FIG 207
Glandular abscess in neck, showing site for incision.

Ludwig's Angina.—This term is applied to a diffuse phlegmon confined between the muscular floor of the mouth and the fascial roofs of the submaxillary and submental triangles Tension within this space gives rise to much pain and toxæmia and leads to marked œdema which may interfere with swallowing or breathing by pushing up the floor of the mouth. Asphyxia may result from œdema of the glottis

Operative treatment should not be delayed Its primary object is to relieve the tension within the confined space and accordingly the incision should be ample and sufficiently deep An oblique incision is made over the prominence of the swelling a little way below the mandible The deep fascia is then incised and a sinus forceps inserted

Free drainage should be provided The risk of oedema of the glottis must be borne in mind

CARBUNCLE

This painful, disabling and sometimes dangerous staphylococcal cellulitis was formerly treated by a variety of methods, but with the advent of penicillin the treatment has become quite standardised

Penicillin should be given as a routine by the intramuscular route In some cases this may be supplemented by local injection of penicillin into the subcutaneous tissues in the vicinity of the affected area

Under such treatment in nearly all cases where the inflammatory process is not far advanced the spread is arrested at once and there is rapid progress to full recovery In advanced cases once the disease has been held in check the pus and sloughs may be evacuated through a cruciform incision

If diabetes is present the appropriate treatment must of course be carried out and in all cases attention must be directed towards restoration of the general health by tonics and the administration of iron.

TUBERCULOUS GLANDS IN THE NECK

Diverse views have been held on the treatment of tuberculous cervical glands some surgeons favouring conservative others operative methods Both types of treatment have their place according to the extent and character of the disease The infection may occur as a local process due to tubercle bacilli that have gained access via the tonsil and spread thence to the regional glands but no further in such cases the rational line of treatment is to remove the affected group of glands—and also the tonsil—provided that the infection is not an actively progressive one and that the local conditions make resection feasible On the other hand, the infection may be part of a widespread process due to organisms carried in the lymph or blood stream from a focus in the lungs or mediastinal glands in such cases conservative treatment is clearly indicated though operation may be required for the evacuation and curettage of a cold abscess.

The recent introduction of streptomycin has brought about a change in the surgeon's attitude towards this disease In some cases if the disease has not progressed to extensive caseation streptomycin alone suffices to arrest its progress or even bring about a cure In late cases with caseation abscess or sinus formation streptomycin is valuable as an adjuvant to surgery

The Operation for Radical Excision.—Typically the glandular mass to be excised consists of the tonsillar gland resting on the angle between the internal jugular and common *facial veins* and a few smaller glands above and below it. This represents involvement of the upper anterior jugular group Glands below the omohyoid muscle are seldom involved.

Sometimes, in addition the upper posterior jugular group is involved, though the individual glands in this situation are generally

small These glands are found embedded in the fat of the upper part of the posterior triangle of the neck and can only be completely extirpated by a block excision of the fat in which they lie

When, as is commonly found there is a single gland of large size, with a number of small glands adjacent many surgeons are content to remove the one gland in the expectation that when the main focus is gone the others will undergo healing It is probably wiser however to perform a more radical excision removing all the glands of the affected group In this way the risk of recurrence is considerably reduced

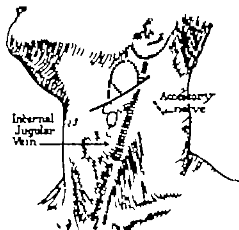


FIG 208

Excision of tuberculous glands in neck. The diagram shows the relation of the *jugular-digastric gland to the internal* jugular and common facial veins and the accessory nerve.

Intratracheal anaesthesia should be used The head is turned to the side and the neck extended over a sand pillow An oblique incision is made lying accurately in a skin crease over the mass and not less than 2 cm below the angle of the jaw The incision is carried through the platysma muscle and the flaps are then reflected upwards and downwards sufficiently to expose the whole carotid triangle By reflecting the two layers as one injury to the cervical branch of the facial nerve is avoided

The external jugular vein is exposed and may be divided The great auricular nerve is seen and retracted The anterior border of the sternomastoid muscle is now defined and the muscle retracted backwards exposing the whole surface of the main glandular mass

The upper margin of the omohyoid muscle is next looked for and the internal jugular vein identified deep to it The glands can then be dissected upwards off the vein The main jugulo-digastric or tonsillar gland lies in close relation to the anterior facial vein and this may require to be ligated

In the upper part of the wound the spinal accessory nerve must be sought and preserved from injury Its situation may be identified by palpating the transverse process of the atlas over which it passes and by seeing the nerve as it enters the deep surface of the sternomastoid muscle at an oblique angle just below that level The nerve is accompanied by the sternomastoid branch of occipital artery injury to which may give warning of the proximity of the nerve

If it is necessary to remove glands of the posterior jugular group the jugular vein is drawn gently forwards and freed from the fat behind it by a few touches of the knife Commencing again at the upper border of the omohyoid muscle the fat in the posterior triangle is divided to expose the prevertebral fascia which forms the floor of the space A strip of fat containing numerous small glands can then be dissected upwards again avoiding the accessory nerve This

manœuvre exposes the loops of the cervical plexus which are not usually disturbed

Hæmostasis must be secured with care before the wound is closed After an extensive dissection a strip of rubber dam should be left in the wound for twenty four hours or inserted through a separate small stab wound in the posterior flap The platysma should be sutured accurately with fine catgut stitches The skin may be closed by a subcuticular stitch or by clips which may be removed after forty-eight hours.

Conservative Treatment—The patient with cervical tuberculosis should undertake the customary antituberculous régime of rest fresh air and a liberal mixed diet Streptomycin should be advised

The stimulant effect of a moving current of fresh air over the unclothed skin surface should be exploited to the full but direct exposure of the affected region to sunshine should be used with care in the earlier stages of the treatment Artificial sunlight while useful in the healing stages should also be avoided or utilised with great care in the active stages of the disease owing to the marked tendency to cold-abscess formation following its use

The Treatment of Cold Abscesses.—Cold abscesses may be treated by repeated aspiration a wide-bore needle being introduced at an angle through as great a depth of healthy tissue as possible Streptomycin should be administered. If despite this treatment the abscess enlarges incision and curettage should not be delayed too long owing to the danger of skin involvement

The abscess is best curetted before the skin becomes discoloured. A small incision is made over the abscess and the contents expressed. A Volkmann s spoon is then introduced and the lining membrane of granulation tissue gently removed, first from the periglandular and then from the intraglandular abscess

If this can be accomplished without causing bleeding the incision may be closed by suture If, on the other hand, the cavity is likely to fill up with blood, it should be packed with ribbon gauze which is removed after a day or two

LIGATION OF COMMON CAROTID ARTERY

Ligation of the common carotid artery is rarely required The main indications are for injury to the vessel and for aneurysm Its use in the treatment of congenital hydrocephalus is now *obsolete*

The operation is a simple one but carries a serious risk of hemiplegia This complication may be expected in 25 per cent of patients over the age of forty

A transverse incision is made in the natural line of skin cleavage with its centre over the anterior border of the sternomastoid muscle at the level of the *cricoid cartilage*. The flaps are retracted, the deep fascia is divided, and the sternomastoid muscle retracted backwards

The carotid sheath is opened at the upper border of the omohyoid muscle The jugular vein thus exposed, is retracted laterally to give

access to the artery In passing the ligature care must be taken not to include the vagus which lies posteriorly between the artery and vein

LIGATION OF EXTERNAL AND INTERNAL CAROTID ARTERIES

External Carotid Ligation may be required for the control of secondary hæmorrhage from septic wounds or from tumours in the tongue or face

Internal Carotid Ligation is indicated in the treatment of an arterio-venous aneurysm between the intracranial portion of the artery and the cavernous sinus The operation carries a risk of hemiplegia similar to that described in connection with ligation of the common carotid artery

The incision is a short oblique one in the line of the skin folds starting from the anterior border of the sternomastoid muscle and passing 2 cm. below the angle of the mandible

The deep fascia is incised the lingual and facial veins are exposed —and divided if necessary—and the hypoglossal nerve is drawn upwards

At its origin the external carotid lies slightly superficial and anterior to the internal carotid In case of doubt it can be readily identified by the presence of its branches The ligature is best applied between the superior thyroid and lingual branches

The internal carotid is exposed by drawing the external trunk forwards Care must be taken not to injure the internal jugular vein which frequently overlaps it The vagus nerve lies deep to the artery and must not be included in the ligature

C F W I

CHAPTER XXV

AFFECTIONS OF THE THYROID GLAND

CONGENITAL ABNORMALITIES

Lingual Thyroid

In this rare anomaly a mass of thyroid tissue is embedded in the posterior part of the tongue The tumour may represent the whole of the thyroid substance or there may be a partially developed gland in the normal situation. The lingual thyroid tends to grow slowly and may cause hæmorrhage dyspnœa or dysphagia

Removal of the lingual thyroid may lead to myxœdema but if the mass is causing serious symptoms this risk must be accepted The excised gland may be transplanted to a less disabling position but this is rarely effective and administration of thyroid extract will then have to be continued throughout life

In most cases a lingual thyroid can be removed through the mouth Anæsthesia is administered through a laryngeal tube and the mouth is held widely open by a mouth gag The tongue is pulled forwards by means of a traction stitch through its tip and the tumour shelled out by the finger or removed by blunt dissection after division of the very thin mucosa covering it Hæmorrhage is temporarily controlled by plugging and finally the cavity in the tongue is obliterated by stitches.

If the tumour is very large or is mainly in the substance of the tongue it is better to remove it through a cervical approach A slightly curved transverse incision is made above the hyoid bone the platysma is divided, and the deep fascia and the median raphe of the mylohyoid split Separation of the geniohyoid muscles discloses the tumour which can then be enucleated.

Thyroglossal Cysts and Fistulæ

Cysts and fistulæ of the anterior midline of the neck arise in remnants of the thyroglossal tract or duct which in the embryo extends from the foramen cæcum in the floor of the mouth to the thyroid gland.

The typical *thyroglossal cyst* lies below or at the level of the hyoid bone Suprahyoid cysts are very rare and are dealt with on the same lines as the lingual thyroid. The infrahyoid cysts are superficially placed, and in most of them a distinct cord representing the remains

of the tract can be traced upwards for a variable distance and commc as far as the hyoid bone

A *thyroglossal fistula* is almost always secondary to a cyst in wh suppuration or trauma has destroyed the covering skin. The open may be close to or some distance below the hyoid bone and is of obscured by a crescentic fold of skin. As in the case of the cys cord like tract can generally be traced upwards and made promin by asking the patient to swallow

Operations for thyroglossal anomalies are attended by a h recurrence rate unless the whole tract is completely removed view of the very intimate relationship to the hyoid bone it is h that the resection is most likely to be inadequate and if the tr extends to this level the central part of the body of the hyoid must removed *in continuity with it* If *it extends even more proxima* the resection should be continued into the posterior third of the tong

The neck is well extended and a transverse incision is made o the cyst in one of the natural creases of the skin in the case o fistula the incision embraces the aperture The investing layer of cervical fascia is divided the cyst or fistula defined, and the fibr cord or tract traced upwards to the hyoid At this point the lov part of the mylohyoid raphe is split and the central part of the hy bone is cleared and divided on each side about ¼ in from the midli If a further portion of tract passes upwards into the tongue a cent core of tissue containing it should be defined by means of a narrc bladed knife this step is rendered easy if the assistant passes his ind finger into the mouth and presses the base of the tongue downwar and forwards to shorten the distance between the hyoid bone and t foramen cæcum

TOXIC GOITRE

The evidence is now clear that the hyperthyroid state can at le be controlled and sometimes cured by the administration of certa thiourea derivatives of which methyl thiouracil and propyl thioura are the most potent These drugs act by preventing the synthesis the thyroid secretion and clinical improvement occurs rapidly aft a short latent period of a week or two

Surgery —The belief that they would supersede surgery has n been substantiated *and the exact place of operation has not as y* been defined Mild primary thyrotoxicosis especially in young subjec may be cured by thiourea and severe thyrotoxics can be controlle certainly for as long as the drug is exhibited and probably for a lo time afterwards

A number of patients fail to respond however and a numb develop toxic drug reactions after a long period of apparent toleranc Furthermore the gland *is the site of considerable cellular activit* and of increased vascularity occasionally it may even undergo co siderable enlargement under treatment

In secondary toxic goitre the symptoms are usually improved bu not completely abolished by thiourea and the swelling and nodularit of the gland persist or increase

The recognised indication for surgery at present, therefore, are

In *primary thyrotoxicosis*

1 Failure to respond—or slow response to thiourea
2 The occurrence of toxic manifestations—leucopenia agranulocytosis fever, vomiting, skin eruptions œdema of the feet and legs, and enlargement of the lymph nodes
3 Enlargement of the gland with or without pressure effects under treatment
4 Relapse after apparent cure
5 When economic or social circumstances make prolonged convalescence or prolonged medical supervision difficult or impossible

In *secondary toxic goitre*, operation is probably the treatment of choice

The mortality from thyroidectomy is now insignificant, but fatalities are unquestionably related to the intensity of the thyrotoxicosis The considerable reduction in the level of toxicity effected by the thiourea group of drugs gives them an important place in the pre-operative preparation of patients selected for thyroidectomy other than those who have exhibited evidences of drug intolerance

Pre-operative Preparation.—In severe cases the pre-operative preparation should include a period of thiourea therapy unless the patient is unresponsive or there are signs of idiosyncrasy or pressure symptoms The usual dose is 0 2 gm. of methyl or propyl thiouracil, and provided the patient is kept under regular medical supervision and warned to report immediately if there is a sore throat or other evidence of drug toxicity, this period of preparation can be conducted as an out-patient

There is no doubt that thiouracil makes thyroidectomy more difficult because of the increased vascularity of the gland and therefore the final preparation—after the maximal response to thiourea is obtained —is a course of iodine therapy This should last two to three weeks and for a part of this time the patient may be treated at home A regular sedative should be prescribed for example 1 gr phenobarbitone twice daily The diet should be a generous one and glucose should be given also

Iodine is usually administered in the form of Lugol s solution (5 per cent iodine with 7 5 per cent potassium iodide in water) in doses of 5 to 15 minims daily It is equally satisfactory to give sodium iodide alone in doses of half a grain twice daily

The heart is often affected seriously in toxic goitre Apart from simple tachycardia there may be severe myocarditis with auricular fibrillation and congestive heart failure Simple tachycardia responds well to rest thiouracil and iodine and requires no other medication but special pre-operative measures may be required for the more severe types of heart failure Auricular fibrillation should be controlled by digitalis, while in congestive heart failure it may be necessary to employ diuretics and to restrict salt and water

Anæsthesia.—The thyrotoxic patient should come to operation

under the influence of a basal narcotic Scopolamine is often used, but has the disadvantage that it sometimes acts as an excitant Preference should therefore be given to rectal paraldehyde (1 dram per 14 lb body weight) or avertin (0 1 gm per kilo) These drugs should be administered one hour before operation.

Local or general anæsthesia may be used Local anæsthesia facilitates the dissection and reduces the risk of respiratory complications In nervous patients intravenous pentothal is satisfactory If inhalation anæsthesia is desired preference should be given to nitrous oxide and oxygen or cyclopropane administered by intratracheal tube

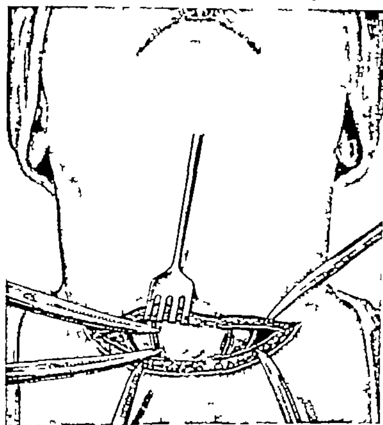


FIG. 209

Thyroidectomy The skin and platysma have been divided, and the anterior jugular veins exposed.

Operative Technique.—The routine procedure is subtotal thyroidectomy in which about seven-eighths of the gland is removed.

The patient is placed with the shoulders raised and the neck extended over a small pillow A collar incision is used It lies in or parallel to one of the natural skin creases about 2 cm above the sternum and extends on either side to the posterior border of the sternomastoid muscle The flaps consisting of skin and platysma are dissected up and the anterior jugular veins divided between ligatures (Fig 209) The deep fascia and sternohyoid and sternothyroid muscles are now split in the midline and retracted to either side If necessary to obtain access, the muscles may be divided transversely close to their upper attachment. The pretracheal fascia is divided and the gland exposed (Fig 210)

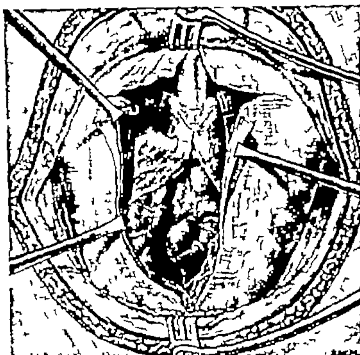


FIG 210

Thyroidectomy The deep fascia has been divided in the midline, and the pretracheal muscles cut across near the thyroid cartilage. The thyroid gland is displayed after the pretracheal fascia is divided.

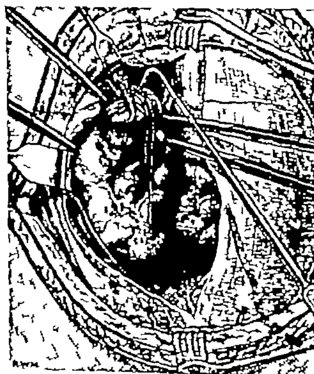


FIG 211

Thyroidectomy Ligation of superior thyroid vessels on right side.

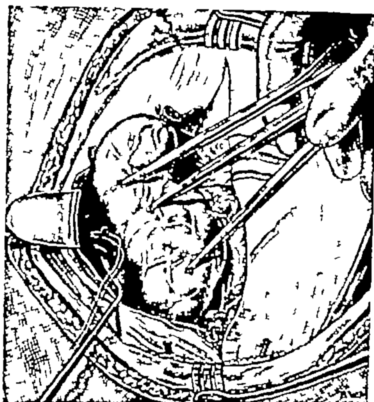


Fig 212.

Thyroidectomy The middle thyroid veins have been secured, and a ligature is being passed round the inferior thyroid artery away from the gland.

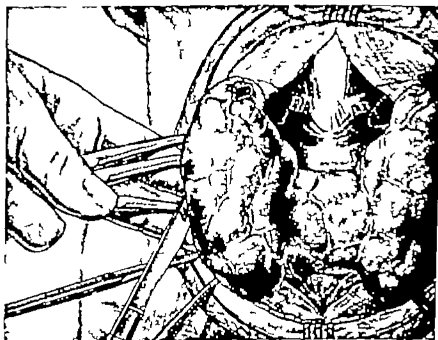


Fig 213

Thyroidectomy The vessels of the opposite lobe have been dealt with, and the resection is begun on the right side.

The lateral lobes of the gland are defined in turn The upper pole is drawn gently forwards and downwards and the superior thyroid vessels thus put on the stretch are ligated and divided (Fig 211) The middle and inferior thyroid veins are also exposed ligated and divided The remaining large vessel the inferior thyroid artery, may be ligated in continuity where it crosses behind the carotid sheath before reaching the gland but this step is necessary only if the gland is very vascular (Fig 212)

Subtotal resection is then carried out (Fig 213) The portion left behind takes the form of a thin slice of the posterior part of each lateral lobe so that damage to the recurrent nerve and the parathyroid glands is avoided (Fig 214) Hæmorrhage from the cut surfaces is

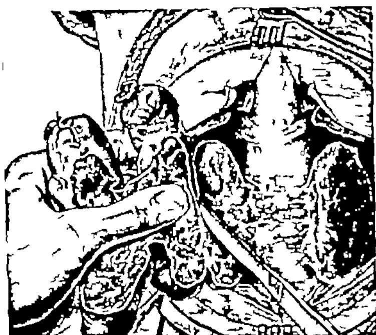


FIG 214

Thyroidectomy The resection is nearing completion, a small portion of each lateral lobe being left behind.

controlled by picking up bleeding points and under running them with a fine suture The wound is then closed drainage being provided to guard against the risk of a hæmatoma

Post-operative Care.—For the first few days the patient should be nursed in seclusion, and opiates may be required to control restlessness Since the metabolic rate is usually high and the temperature may be raised, few bedclothes should be used and the room must be cool and airy Fluids should be given in abundance After the second day the appetite is generally restored and a generous diet may be given. Iodine may be continued for a week or two

In the great majority of cases recovery is very rapid. Often the patient can be allowed up on the seventh or eighth day and home a week later Work may be resumed after a month or so

The recovery in most respects is usually complete Thus the basal

metabolic rate returns to normal the nervousness and tremors pass off weight is gained and even severe heart damage undergoes marked improvement The exophthalmos often persists however and may even grow worse

Complications.—*Acute dyspnœa* with *stridor* may occur as a result of the accumulation of blood clot under the taut pretracheal muscles with consequent compression of the trachea It demands urgent treatment which consists of opening up the wound to evacuate the clot The bleeding is then arrested by forcipressure or by packing

Paralysis of the recurrent nerve may appear at once if there has been a direct injury to the nerve or several hours later as a result of pressure on the nerve by œdema or blood clot In the latter case the paralysis may be bilateral and urgent dyspnœa may result The wound should be opened up and any clot evacuated If this fails to relieve the distress tracheotomy may be required

Injury to the superior laryngeal nerve leads to a loss of the cough reflex and thus predisposes to respiratory complications

Acute thyrotoxic crisis is a rare but dangerous complication All the features of thyrotoxicosis are present in an exaggerated form with high fever restlessness delirium and tachycardia proceeding to cardiac failure The treatment should be energetic The temperature is controlled by cold sponging or by ice-packs and iodine is given in large doses 5 gr of sodium iodide may be given intravenously followed by Lugol s iodine by the mouth Morphia is repeated as often as is required to control the restlessness Glucose saline solution is given intravenously in large amounts to preserve the fluid balance Digitalis is administered if fibrillation develops

Tetany may result from removal of the parathyroid glands or from temporary interruption of their function from œdema The latter is more common

In mild tetany—for example cases with numbness in the arms and slight carpopedal spasms—the symptoms may be relieved by the intramuscular injection of 20 units of parathormone which raises the serum calcium to the normal level in about six hours and maintains it at that level for twenty four hours or so The injection may be repeated as required.

In severe tetany especially if laryngeal spasms develop the serum calcium should be restored immediately to the normal level by the intravenous injection of 20 c c 20 per cent calcium gluconate or 5 to 10 c c 10 per cent calcium chloride

Where the tetany is long continued the blood calcium level may be maintained by administering calcium by giving acidifying substances, and by injecting parathyroid hormone Calcium lactate or calciferol should be given by the mouth and the diet must be generous in milk. Vitamin D in large doses facilitates absorption of calcium from the intestinal tract The acidifying substances to be advised are ammonium chloride (in doses of 30 gr in extract of liquorice) or hydrochloric acid (300 c c of decinormal solution to 2 litres of milk) Parathormone may aslo be necessary to maintain the blood calcium level—the dose which must be controlled by estimations of the blood calcium may

selected should be firm to prevent obstruction as the goitre is manipulated through the thoracic aperture

A low collar incision is used The affected lobe is exposed mobilised by division of its vessels and drawn forwards A finger is then passed along its posterior surface into the mediastinum and the adenoma freed within its capsule If it is not too large it may then be displaced upwards into the neck the mediastinal cavity packed temporarily, and the operation completed by enucleation of the adenoma or subtotal resection of the lobe If the adenoma is larger and cannot be dislocated from behind the sternum it may be removed piecemeal or if cystic its bulk can be reduced by aspiration. If the adenoma is so fixed by adhesions or malignant invasion that a line of cleavage cannot be found it may be necessary to gain further access In this event the manubrium may be split in the midline and sawn across transversely at its junction with the sternum the two halves being then retracted strongly Alternatively the clavicle and costal cartilages may be divided on the affected side

LYMPHADENOID GOITRE (HASHIMOTO'S DISEASE)

This form of goitre occurs in women at or after the menopause and is characterised by a tendency to hypothyroidism due to the progressive replacement of the thyroid tissue by lymphocytic infiltration and by a tendency to mild pressure symptoms

It may respond to radiotherapy which should certainly be employed in the first instance Surgical treatment is indicated when pressure symptoms fail to subside after radiotherapy the operation should consist of a subtotal resection but relatively more of the gland is left than in the operation for toxic goitre and the main arteries to the gland should not be ligated It must be borne in mind that hypothyroidism develops rapidly in the post-operative period administration of thyroid extract must therefore be begun at once to prevent myxœdema

RIEDEL'S GOITRE (LIGNEOUS THYROIDITIS)

This form of goitre is characterised by fibrosis which spreads not only in the gland itself but beyond its capsule to involve muscles vascular sheaths the trachea and the œsophagus

If untreated it generally proves fatal in consequence of pressure effects Radiotherapy is unavailing and removal of enough gland to relieve pressure must be undertaken The operation involves resection not only of the affected part of the gland but also of the covering muscles and no matter how great the difficulty sufficient tissue must be removed to relieve the pressure symptoms

MALIGNANT TUMOURS OF THE THYROID

The respective place of operation and radiotherapy alone or in combination in the management of carcinoma of the thyroid gland is

not yet established If the disease arises within a pre-existing adenoma or forms a circumscribed tumour with little evidence of invasion—the *malignant adenoma*—it should be removed completely along with any enlarged glands on that side of the neck and with the *internal jugular vein* if there is any suggestion of vascular involvement Subsequently deep X ray therapy is indicated

If the disease is infiltrating diffusely or if its extent is large or its development rapid radiotherapy should be advised in the first place Some growths are very responsive to irradiation and only those which are resistant should be submitted to operation In such cases complete removal is not to be expected and the aim of operation is to remove as much of the growth as possible and certainly sufficient to relieve the pressure on the trachea

TUMOURS OF THE PARATHYROID GLANDS

The only tumour encountered with any frequency in the para thyroid glands is a simple adenoma It is usually associated with hyperparathyroidism manifested clinically by generalised osteitis fibrosa cystica and an upset in calcium and phosphorus meta bolism The tumour itself is so small and soft and often so deeply placed that it cannot usually be recognised by palpa tion, so that when generalised fibrocystic disease of bone is suspected, the diagnosis of a parathyroid tumour depends on the demonstration of altered calcium and phosphorus values in the blood serum The serum calcium is raised generally to 12 or 13 mg per cent occasion ally much higher — and the plasma phosphorus level falls to about 2 5 mg per cent Occasionally if the renal threshold is low the serum calcium lies within the normal limits *in such cases the urinary output of calcium is greatly increased* The presence of bilateral renal calculi may give further evidence of the calcium disturbance

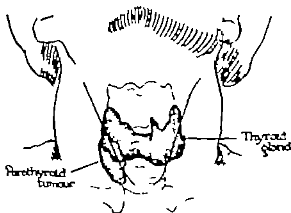


FIG 215
Tumour of right inferior parathyroid gland.

Exposure of the parathyroid tumour may be very easy or very difficult according to its situation in the neck. If the tumour has originated in one of the superior parathyroid glands its exposure generally is simple for these glands lie between the capsule of the thyroid and its fascial sheath and are situated constantly behind the lateral lobes of the thyroid The inferior glands on the other hand sometimes lie *outside the fascial sheath* and a tumour arising from one of them may descend into the thorax either in the anterior mediastinum *or even behind the œsophagus*

The exposure is the same as for thyroidectomy (p 444) The lateral lobes of the thyroid are gently mobilised and the tumour is sought behind or inferior to them The middle thyroid veins may be tied and divided to facilitate this step If the tumour is not found here the search is continued lower down on each side of the trachea and into the mediastinum When the tumour has been located it can be removed with ease after ligation of the small vessels branches of the thyroid arteries which supply it

After removal of the tumour there is a risk of tetany owing to the sudden depletion of parathyroid hormone Fortunately this is nearly always a temporary phase for the remaining parathyroid glands soon resume their normal function The treatment of tetany is described on p 448

J B

CHAPTER XXVI

AFFECTIONS OF THE LARYNX, PHARYNX, AND ŒSOPHAGUS

RELIEF OF RESPIRATORY OBSTRUCTION

SUDDEN or progressive respiratory obstruction may result from diphtheria retropharyngeal abscess œdema of the glottis or an impacted foreign body more gradual obstruction may result from a tumour within the larynx or trachea or one occluding the air passages by pressure from without e g tumours of the thyroid gland In some of these conditions the obstruction is best relieved by surgical or irradiation treatment of the causal condition in others relief must be gained by intubation or tracheotomy

Laryngeal Intubation.—*Intubation is useful in the treatment of* respiratory obstruction due to laryngeal diphtheria It is a procedure requiring considerable skill and experience and consequently it is seldom practised save by medical officers in fever hospitals Its chief advantages are that it can be performed rapidly and provides an ample airway its disadvantages are that it demands the constant care of a medical attendant (lest the tube be expelled), and that if continued more than a week or so it may cause ulceration of the larynx and so lead to stenosis

O'Dwyer's intubation outfit is convenient It consists of fluted vulcanite tubes of various sizes with an introducer and holding appliances The tube is introduced under direct vision and secured to the cheek or teeth by wire threads Subsequently careful nursing is essential If dysphagia is caused, it may be necessary to feed the child through a nasal tube The nurse should be warned to call medical aid immediately if the tube becomes blocked with exudate or is expelled Generally the tube is retained in place for two to four days

Laryngotomy —This is the simplest and most speedy method of relieving urgent obstruction to respiration due for example to a foreign body in the larynx Owing to the narrowness of the crico-thyroid space however it is a somewhat difficult procedure in children The operation is carried out readily under local anæsthesia or in an emergency without anæsthesia The patient is placed with the neck fully extended A short transverse incision is made immediately above the cricoid cartilage and deepened to expose the crico thyroid membrane which is then incised transversely If available a laryngotomy tube which resembles a tracheotomy tube but is oval in cross-section may be inserted A tube is not essential however since the thyroid and cricoid cartilages tend to spring apart when the

intervening membrane is divided—a further advantage of the procedure in an emergency

Tracheotomy—This operation now seldom required, may be performed in preference to intubation in laryngeal diphtheria, and is done sometimes as an emergency procedure in other forms of respiratory obstruction It is indicated also for progressive obstruction by malig nant tumours of the larynx pharynx and thyroid gland

The trachea may be opened at the level of its second and third ring (high tracheotomy) or at a lower level (low tracheotomy) The former is much to be preferred owing to the ease with which it may be accomplished and should always be chosen except in cases where the nature of the obstruction (such as a carcinoma of the thyroid gland) renders the lower ex posure imperative

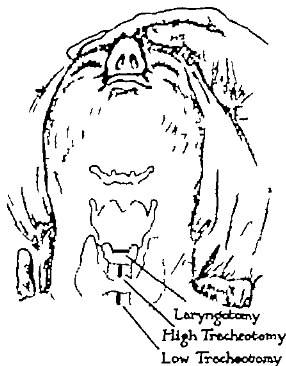


FIG 216

Tracheotomy The assistant holds the head straight, with the neck fully extended

When the respiratory ob struction is not acute the operation may be performed without haste and presents no special difficulty Under circumstances of urgency on the other hand it is far from easy and may call for considerable resource when conducted in surroundings which demand hurried im provisation of lighting equipment and assistance

It is important to have the patient placed in the proper position with the neck fully extended and the head exactly in the sagittal plane A child should be held as illustrated in Fig 216 The slightest rotation of the head displaces the trachea to the side and may cause difficulty in exposing it Similar difficulty arises if the trachea is displaced laterally by a growth

The anæsthetic must be suited to the patient s condition In an acute emergency there is no time available and moreover an anæsthetic is unnecessary as the sensitiveness to pain is dulled In less urgent conditions local infiltration with 1 per cent novocaine gives sufficient anæsthesia while in favourable cases chloroform may be used Nitrous oxide and ether are obviously unsuitable as also an intravenous anæsthetic

A transverse incision is generally suitable Its mid point lies in the middle line about half a centimetre below the cricoid cartilage which can readily be identified a short distance below the prominence of the

in place by tapes tied round the neck The wound may be lightly closed and covered with flavine gauze

Post-operative care must be directed towards keeping the airway clear The nurse should be instructed to keep the tube cleansed and free from tenacious mucus The patient should be propped up and sulphadiazine and penicillin may be given to limit the risk of bronchopneumonia

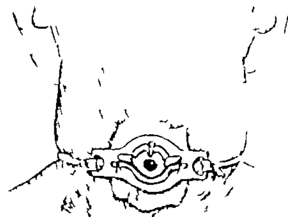


FIG 210
Tracheotomy Tube held securely by tape attached to flange Inner tube in place

The tube should be withdrawn *as soon as practicable* in order to avoid ulceration and necrosis of the tracheal wall which might lead to *stenosis* *Usually it may be* removed on the second or third day The patency of the larynx may be tested by introducing an obturator into the tube (preferably while the child is asleep) In practice however it is equally satisfactory simply to withdraw the tube and to reinsert it if there is any respiratory distress If the tube has to be kept in place longer it should be removed periodically for cleansing

In *low tracheotomy* the skin incision is made at a lower level in the neck and the trachea is exposed below the isthmus of the thyroid gland The steps of the operation are similar but owing to the depth of the trachea at this level and the presence of large distended veins or enlargement of the thyroid gland the access is somewhat difficult

FOREIGN BODIES IN THE AIR AND FOOD PASSAGES

Foreign Bodies in the Larynx.—A large foreign body such as a bone or a denture blocking the larynx causes rapidly fatal asphyxia a small one gives rise to acute dyspnœa with spasmodic cough and recurring fits of choking which threaten suffocation

The treatment in an emergency is to perform laryngotomy or tracheotomy

If the symptoms are not urgent the throat should be sprayed with anathane (1 per cent) and an attempt made to extract the body through a laryngoscope If this proves impossible it will be necessary to open the larynx by median laryngo-fissure (p 463)

Foreign Bodies in the Bronchi.—Foreign bodies aspirated into the bronchi generally lodge in one of the bronchi of the lower lobe of the lung *especially on the right side* *The diagnosis is not always easy* nor the history conclusive for though in most cases at the time of *aspiration there is a* sharp fit of coughing or choking these symptoms

soon pass off and moreover may readily be missed if the body is aspirated during sleep or intoxication or anæsthesia X ray examination will usually reveal an opaque body and in other cases may provide collateral evidence such as a localised area of collapse or a focus of pulmonary suppuration

If undertaken early removal of the body can usually be effected by means of a bronchoscope under local anæsthesia If the body is of soft material such as a nut or a pea its extraction should be attempted without delay—preferably within twenty four hours—for such objects harbour organisms and often lead to severe infective complications and moreover they become rapidly obscured by œdematous swelling of the bronchial mucosa The removal of hard or metallic bodies is less urgent

It is sometimes an advantage to carry out the bronchoscopy under the fluorescent screen In rare instances if repeated attempts at removal prove unsuccessful it may be necessary to perform thoracotomy to extract the foreign body through an incision in the lung If the lung has become the seat of suppuration resection of the affected segment will be necessary

Foreign Bodies in the Pharynx.—An object impacted at the level of the glottis may obstruct the airway and if attempts at digital or instrumental removal fail, may demand immediate laryngotomy or tracheotomy to avert death from suffocation

An object *e g* a denture impacted at a lower level gives rise to less acute symptoms and immediate extraction is not imperative Extraction however should not be unduly delayed for there is a risk—especially if the object is pointed or of irregular shape—that it may perforate the thin pharyngeal wall and give rise to cellulitis of the neck and mediastinum

Generally the object can be extracted through a pharyngoscope under general or local anæsthesia If this fails operative removal is necessary The pharynx is exposed through an oblique or transverse incision on the left side of the neck as described in the treatment of pharyngeal pouch (p 459) Moist packs are then inserted into the wound to isolate the affected part and protect the cellular tissue planes of the neck and mediastinum The object can usually be palpated through the pharyngeal wall and removed through a short incision placed directly over it If the mucous membrane is sutured accurately leakage seldom occurs A pack should be left in place and the skin wound either left open or sutured lightly

Foreign Bodies in the Œsophagus.—The commonest objects to lodge in the œsophagus are coins fish or meat bones pins and dentures Impaction may occur at any level, but most commonly near the upper end of the œsophagus a short distance below the level of the cricoid cartilage

The diagnosis is by no means easy for accurate details of the accident may not always be forthcoming and the doubts and fears of an apprehensive patient or relatives may be misleading For this reason radiography should always be carried out If the suspected foreign body is non-opaque to X rays a thin emulsion of barium may

outline it If doubt still remains the diagnosis may be established by *œsophagoscopy* this applies especially to fragments of bone and to portions of dentures made of plastic materials

Generally such acute symptoms as occur at the time of impaction soon settle leaving only slight pain on swallowing *consequently* there is no urgency in treatment If the object is smooth and rounded it may be given an opportunity to dislodge itself Even if it is sharp-pointed and firmly impacted precipitate interference is to be condemned unless expert assistance is available The old fashioned probangs coin-catchers and other blind instruments were more dangerous than the foreign body itself Removal of the foreign body should be effected under direct vision through an œsophagoscope and for this purpose every effort should be made to obtain the services of a skilled endoscopist even if this involves transporting the patient a long way to a suitable centre

Removal of a sharp-edged foreign body in the thoracic part of the œsophagus should not be too long delayed lest ulceration into large blood vessels occurs

Many special instruments have been devised for grasping different types of foreign body for disimpacting sharp-pointed objects and for closing open safety pins or rendering them harmless

Operation is required in the rare cases in which attempts at endoscopic removal prove unsuccessful In such circumstances approach to the œsophagus is gained by an incision in the lower part of the left side of the neck as for a foreign body in the pharynx Thoracotomy is needed if the foreign body has lodged in the thoracic portion of the œsophagus

RETROPHARYNGEAL ABSCESS

Acute Retropharyngeal Abscess.—This abscess is generally due to an acute *pyogenic infection of the retropharyngeal lymph glands* The abscess bulges into the pharynx and must be opened through the pharynx The child is placed supine with the head hanging over the end of the table so that pus may flow back into the nasopharynx or alternatively upon the side so that the child may quickly be turned face downwards

As a rule no anæsthetic is utilised owing to the danger of rupture of the abscess during *induction and consequent inhalation of pus* with pulmonary complications If it is impossible otherwise to control the child a brief chloroform anæsthesia is preferable to ether as it causes less struggling

The mouth is held open with a gag and the point of a scalpel plunged into the abscess In order to avoid injury to deeper structures the scalpel should be guarded to within ¼ in of the point by adhesive strapping wrapped round the blade

During the after treatment it should be remembered that sudden death may result from yeilding of the transverse ligament of the atlanto-axoid joint which is hyperæmic and softened from proximity to the infective process

Tuberculous Retropharyngeal Abscess.—Two types of tuberculous abscess occur behind the pharynx The commoner arises as a complication of spinal disease Since the abscess lies deep to the prevertebral fascia it bulges into the pharynx to a certain extent but shows little tendency to burst in this direction Instead it tracks laterally penetrates the prevertebral fascia in the floor of the posterior triangle of the neck and points at the posterior border of the sternomastoid muscle

The second type now very rare results from tuberculosis of the retropharyngeal lymph glands The abscess lies in front of the prevertebral fascia and is thus liable on rupture to subject both digestive and respiratory tracts to contamination This type is generally associated with active and obvious tuberculous adenitis in infants who have acquired a massive tuberculous infection

On no account must a tuberculous abscess be incised through the pharynx It is easily evacuated by an incision along the posterior margin of the sternomastoid muscle the abscess being entered behind the carotid sheath.

PHARYNGEAL DIVERTICULUM

A pharyngeal diverticulum occurs mainly in elderly male patients It causes increasing dysphagia and thus leads eventually to a state of inanition Inhalation of septic contents regurgitated from the pouch may give rise to bronchitis or bronchopneumonia

Surgical treatment affords complete and lasting relief of the dysphagia The risks of operation chiefly associated with infection have been practically eliminated so that removal of the diverticulum in one stage is now the usual practice One-stage excision has replaced the earlier methods such as pharyngopexy and two-stage removal of the diverticulum In pharyngopexy the diverticulum was liberated and its fundus transposed and fixed higher up in the neck so that the pouch did not fill during deglutition The procedure usually relieved dysphagia more or less completely but the patient remained aware of an annoying gurgling noise on swallowing

Before operation for a pharyngeal pouch a period of preparation is advisable Carious teeth should be extracted. The patient should be taught to keep the pouch empty by adopting a bend low posture from time to time Penicillin should be given parenterally for forty eight hours preparatory to and also after operation to control infection In elderly patients with severe malnutrition protein hydrolysate should be given while occasionally even a temporary gastrostomy is required

The operation may be carried out under general or local anæsthesia Cyclopropane given by intratracheal tube is satisfactory Most surgeons prefer local anæsthesia by infiltration it is surprisingly free of discom fort to the patient

The pouch is generally approached from the left side of the neck, through an incision along the anterior margin of the sternomastoid muscle or an oblique incision in the line of skin cleavage The carotid sheath is exposed and retracted laterally The infrahyoid muscles are

outline it If doubt still remains the diagnosis may be established by œsophagoscopy this applies especially to fragments of bone and to portions of dentures made of plastic materials

Generally such acute symptoms as occur at the time of impaction soon settle leaving only slight pain on swallowing consequently there is no urgency in treatment If the object is smooth and rounded it may be given an opportunity to dislodge itself Even if it is sharp-pointed and firmly impacted precipitate interference is to be condemned unless expert assistance is available The old fashioned probangs coin catchers and other blind instruments were more dangerous than the foreign body itself Removal of the foreign body should be effected under direct vision through an œsophagoscope and for this purpose every effort should be made to obtain the services of a skilled endoscopist even if this involves transporting the patient a long way to a suitable centre

Removal of a sharp-edged foreign body in the thoracic part of the œsophagus should not be too long delayed lest ulceration into large blood vessels occurs

Many special instruments have been devised for grasping different types of foreign body for disimpacting sharp pointed objects and for closing open safety pins or rendering them harmless

Operation is required in the rare cases in which attempts at endoscopic removal prove unsuccessful In such circumstances approach to the œsophagus is gained by an incision in the lower part of the left side of the neck as for a foreign body in the pharynx Thoracotomy is needed if the foreign body has lodged in the thoracic portion of the œsophagus

RETROPHARYNGEAL ABSCESS

Acute Retropharyngeal Abscess.—This abscess is generally due to an acute pyogenic infection of the retropharyngeal lymph glands The abscess bulges into the pharynx and must be opened through the pharynx The child is placed supine with the head hanging over the end of the table so that pus may flow back into the nasopharynx or alternatively upon the side so that the child may quickly be turned face downwards

As a rule no anæsthetic is utilised owing to the danger of rupture of the abscess during induction and consequent inhalation of pus with pulmonary complications If it is impossible otherwise to control the child a brief chloroform anæsthesia is preferable to ether as it causes less struggling

The mouth is held open with a gag and the point of a scalpel plunged into the abscess In order to avoid injury to deeper structures the scalpel should be guarded to within ¼ in of the point by adhesive strapping wrapped round the blade

During the after treatment it should be remembered that sudden death may result from yeilding of the transverse ligament of the atlanto-axoid joint which is hyperæmic and softened from proximity to the infective process

Tuberculous Retropharyngeal Abscess—Two types of tuberculous abscess occur behind the pharynx The commoner arises as a complication of spinal disease Since the abscess lies deep to the prevertebral fascia it bulges into the pharynx to a certain extent but shows little tendency to burst in this direction Instead it tracks laterally penetrates the prevertebral fascia in the floor of the posterior triangle of the neck, and points at the posterior border of the sternomastoid muscle

The second type now very rare results from tuberculosis of the retropharyngeal lymph glands The abscess lies in front of the pre vertebral fascia and is thus liable on rupture to subject both digestive and respiratory tracts to contamination This type is generally associ ated with active and obvious tuberculous adenitis in infants who have acquired a massive tuberculous infection

On no account must a tuberculous abscess be incised through the pharynx It is easily evacuated by an incision along the posterior margin of the sternomastoid muscle the abscess being entered behind the carotid sheath

PHARYNGEAL DIVERTICULUM

A pharyngeal diverticulum occurs mainly in elderly male patients It causes increasing dysphagia and thus leads eventually to a state of inanition Inhalation of septic contents regurgitated from the pouch may give rise to bronchitis or bronchopneumonia

Surgical treatment affords complete and lasting relief of the dysphagia The risks of operation chiefly associated with infection have been practically eliminated so that removal of the diverticulum in one stage is now the usual practice One-stage excision has replaced the earlier methods such as pharyngopexy and two-stage removal of the diverticulum In pharyngopexy the diverticulum was liberated and its fundus transposed and fixed higher up in the neck so that the pouch did not fill during deglutition The procedure usually relieved dysphagia more or less completely, but the patient remained aware of an annoying gurgling noise on swallowing

Before operation for a pharyngeal pouch a period of preparation is advisable Carious teeth should be extracted. The patient should be taught to keep the pouch empty by adopting a bend low posture from time to time Penicillin should be given parenterally for forty eight hours preparatory to and also after operation to control infection In elderly patients with severe malnutrition protein hydrolysate should be given while occasionally even a temporary gastrostomy is required

The operation may be carried out under general or local anæsthesia Cyclopropane given by intratracheal tube is satisfactory Most surgeons prefer local anæsthesia by infiltration it is surprisingly free of discom fort to the patient

The pouch is generally approached from the left side of the neck, through an incision along the anterior margin of the sternomastoid muscle or an oblique incision in the line of skin cleavage The carotid sheath is exposed and retracted laterally The infrahyoid muscles are

retracted medially and the lobe of the thyroid gland is freed and displaced towards the midline The inferior thyroid artery, passing across the field deep to the carotid sheath, is divided between ligatures, with care to avoid damage to the recurrent laryngeal nerve

The pouch which lies deeply in the prevertebral space posterior to the œsophagus is difficult to find for when empty it is much smaller than its radiographic appearance suggests and its wall is thin and lustreless Assistance in the search is afforded by passing a catheter or preferably a lighted œsophagoscope from the mouth into the pouch or the œsophagus

When found the pouch can be freed without difficulty It is

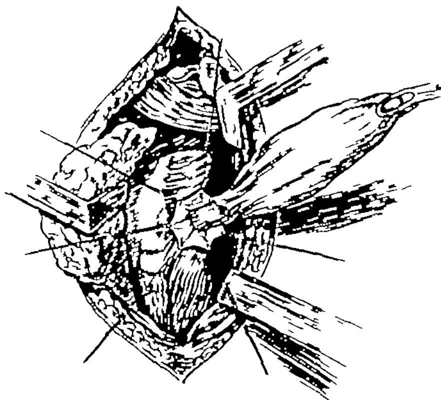


FIG 220

Exposure and removal of a pharyngeal pouch. The pharyngeal aponeurosis is utilised to buttress the suture line at the neck of the pouch.

displaced gently with care to avoid perforating its thin wall If only pharyngopexy is to be done it is fixed in the inverted position by attaching its fundus by a few catgut stitches to the sternomastoid muscle at the upper end of the wound

Excision of the sac is done by dividing the neck of the sac close to the hypopharynx taking care not to drag out a funnel of mucosa from the pharynx A cuff method of division and closure is a safeguard against leakage (Fig 220) Clamps are better avoided as they favour necrosis Closure is usually done by interrupted catgut sutures and as few as possible A light gauze drain is conducted from the bed of the wound Temporary leakage of saliva and liquids occurs in a few instances It is usually delayed for several days though tiresome it

seldom continues for more than two weeks Penicillin instilled into the wound during the first few days after operation is a safeguard against active infection

CARCINOMA OF THE PHARYNX

Most tumours of the pharynx are of squamous cell pattern though some especially those of the nasopharynx and the oral pharynx are of undifferentiated type and are often designated lympho-epithelioma Tumours of the hypopharynx (that part of the pharynx below the epiglottis) are nearly always of well-differentiated squamous cell type

Owing to their deep situation and infiltrative character malignant tumours of the nasopharynx and oropharynx are not amenable to any form of surgical treatment As the tumour may be very radio sensitive deep X ray treatment may bring about considerable and even prolonged relief

Tumours of the hypopharynx are often advanced and the patients in poor condition when the tumour is first discovered and palliative treatment (*e.g* gastrostomy or even tracheotomy) only is possible If the tumour is discovered early and is comparatively circumscribed the choice of treatment rests between irradiation and surgical removal In most centres in Great Britain irradiation is usually adopted there are however many surgeons who favour surgical removal of the tumour despite the allegation that the operations are formidable and mutilating In favour of operation in selected cases it can be claimed that many permanent good results may be obtained and it is probable that surgery should be retained as the method of choice in a young and robust subject with a relatively localised tumour of highly differentiated type On the other hand irradiation with the powerful modern appliances though it often fails to bring about complete cure can *generally be expected to give a considerable measure of relief* and with modern technique its application is safe and free from untoward complications

Radiotherapy —Before treatment is begun the site character and extent of the growth must be determined A tumour in the faucial or tonsillar regions is more amenable to treatment than a hypo pharyngeal (post-cricoid) growth for the former type is not only more accessible but generally more radiosensitive Invasion of the laryngeal cartilages and involvement of the cervical lymph glands are unfavourable features

Preliminary measures may be necessary to eliminate sepsis and improve the general state of the patient Dental sepsis *should be* treated generally by extraction of the affected teeth In post-cricoid carcinoma which commonly occurs as a sequel to long-standing dysphagia with anæmia iron should be administered and blood transfusion is often advisable If the dysphagia is severe a preliminary gastrostomy should be performed.

The method of irradiation varies An accessible tumour of limited extent situated in the faucial region can be dealt with by implantation of radium needles or radon seeds In other cases external radiation is

preferable either by X rays or radium beam In planning the treatment attention must be given both to the primary growth and the regional glands The radiation is directed through numerous ports of entry so as to build up an adequate dose in both zones without administering too much to any part of the affected region

Operative Treatment.—The type of operation usually employed is modelled on that originally devised by Trotter though all manner of technical variations may have to be adopted Its object is to remove the tumour completely and by subsequent plastic manœuvres to reconstitute the pharynx and restore normal swallowing The operation is carried out under general anæsthesia (cyclopropane) after intubation of the trachea The approach to the pharynx is through a skin flap to display the infrahyoid muscles the thyroid gland and the carotid sheath The infrahyoid muscles are divided or sacrificed and the lobe of the thyroid gland on one side is mobilised or removed it may not be possible to conserve the recurrent laryngeal nerve on the side of operation The lateral aspect of the larynx pharynx and œsophagus are widely displayed by erasing the origin of the constrictor muscles from the laryngeal cartilages and by removing the entire ala of the thyroid cartilage subchondrally When the constrictor muscle retracts the hypopharynx becomes relatively voluminous it should be opened remote from the tumour to allow inspection of the full limits of the growth The tumour is cut away with a margin of healthy mucous membrane adjacent to it In many instances the excision may include a large part of the lateral and posterior walls of the pharynx the lamina of the cricoid cartilage and even a segment of the œsophagus Sometimes the disease is found to be more extensive than had been anticipated and to involve not only the pharynx but the laryngeal cartilages as well (extrinsic carcinoma) In these circumstances it may be necessary to extend the excision to include a portion of or even the entire larynx

The pharynx is reconstituted as far as possible by suture and such defect as remains is reduced by inlaying the original skin flap into the prevertebral space where its edges are sutured to the margins of the defect in the pharynx A considerable defect still remains on the lateral aspect of the pharynx but during convalescence this defect shrinks to a surprising extent Feeding is carried out by a tube inserted in the œsophagus from the pharyngeal opening Leakage of saliva occurs from the pharyngeal opening for some time but as the enfolded skin forms a gutter saliva tends to drip towards the œsophagus At the completion of operation the skin wound is left freely open and the deeper structures are treated by regular instillations of penicillin

The commonest complications are bronchopneumonia wound suppuration and occasionally secondary hæmorrhage especially from the superior thyroid artery

In successful cases after several weeks the pharyngeal fistulous gap can be closed and the pharynx reconstituted by elevating flaps of adjacent skin which are turned inwards to occlude and repair the fistulous opening

It is obvious that in surgical operations of this character which are quite unstandardised the operator must combine his boldness with appropriate ingenuity in eradicating disease and repairing the defects it is necessary to create

CARCINOMA OF THE LARYNX

Intrinsic carcinoma of the larynx is amenable to either radiotherapy or surgical removal. In its early stages while the growth is limited to one vocal cord either method of treatment may be relied upon to cure the disease in fully 80 per cent of cases without interfering unduly with phonation. Under these circumstances the choice of treatment is largely a matter for individual preference

In the late stages when the growth has spread beyond the vocal cord the outlook is less promising and of the two forms of treatment radiotherapy is generally preferred Surgical excision at this stage entails the extensive operation of laryngectomy and except by a few is considered only in cases in which the disease has failed to respond to or has recurred after irradiation

Radiotherapy—In carcinoma limited to the vocal cord radium needles are implanted after fenestration of the thyroid cartilage Local anæsthesia may be used if necessary A midline incision is made and the soft tissues are cleared from the lateral surface of the thyroid cartilage on the affected side A 'window' is then cut in the cartilage of suitable dimensions to hold the needles vertically their inactive ends being tucked deep to the hard edges of the opening Every care must be taken not to injure the mucous membrane or encroach upon the growth The strength and spacing of the needles must be calculated with regard to the lethal dose for the tumour cells and the tolerance of the surrounding tissues The threads of the needles are bunched up and embedded in the wound, which is then sutured, the stitches being left long A week later the wound is opened, the needles removed and the sutures tied again

In carcinoma that has extended beyond the vocal cord external radiation may be applied as for carcinoma of the pharynx

Operative Treatment.—In carcinoma limited to the vocal cord the growth is removed by laryngo-fissure Preliminary tracheotomy is not required General anæsthesia is required, usually by careful intratracheal intubation. A local anæsthetic may be used successfully The neck is fully extended over a sand pillow A midline incision is made from the hyoid bone downwards exposing the thyroid and cricoid cartilages The thyroid cartilage is then split in the midline the two halves retracted laterally and the mucous membrane opened. The lower part of the larynx is packed with gauze soaked in cocaine adrenalin solution On the affected side the mucous membrane is then detached from the ala of the thyroid cartilage and the affected portion of the cord excised. Hæmostasis is secured by suture and the wound is closed

In carcinoma that has extended beyond the vocal cord and has

failed to respond to or recurred after irradiation the operation of *laryngectomy* may be considered It is usually carried out under general anæsthesia though some operators prefer local anæsthesia

Access to the larynx and pharynx are secured by the same approach as described for pharyngectomy At an early stage the isthmus of the thyroid gland is divided and each lobe of the gland mobilised and pushed downwards and backwards to allow separation of the trachea from the œsophagus The trachea is divided below its first ring after withdrawing the intratracheal anæsthetic tube The lower cut end of the trachea which tends to retract should be brought out of a stab wound above the manubrium It should be fixed by sutures in such a way that at least a quarter of it protrudes beyond the skin surface Anæsthesia is continued through the tracheotomy The upper cut end of the trachea is gripped and the larynx is pulled forwards and its muscular connections with the pharynx and hyoid bone are divided It is cut away from the mucous membrane of the pharynx leaving as much healthy mucous membrane as possible Sometimes it is possible to close the pharyngeal mucous membrane completely It is usually better to leave a feeding tube in situ and allow healing to occur gradually by granulation. Secondary closure of the pharyngostome by plastic devices is sometimes required If a large portion of the pharynx has required removal subsequent reconstruction of the passage by skin tubes and flaps may be necessary

Recently tubes made of tantalum gauze invested by fascia have proved useful in refashioning both the pharynx and the trachea the practice is still in the stage of trial but it seems to afford promise of success in reconstructing seemingly inseparable defects

The voice after removal of the larynx is faint and whispered but by training and by air swallowing a co-operative and intelligent patient may be able to augment it very considerably It is usual to give the patient instruction in air swallowing (into the upper œsophagus) for some time before operation

CARCINOMA OF THE ŒSOPHAGUS

Carcinoma of the œsophagus is usually of well differentiated squamous cell pattern though adenocarcinoma is quite common in the distal portion It is commonest in elderly persons (especially men) and may reach an advanced stage before treatment is sought and the patient is found to be emaciated and debilitated and ill-suited for anything but the palliative measures described below Sometimes however the patient is younger and robust and the tumour is circumscribed and its surgical removal is worth consideration Very notable advances have been made in the technical aspects of resection of the œsophagus so that operation can now be embarked upon with some prospect of success especially if the tumour is situated in the distal third of the œsophagus or at the cardiac end of the stomach (see also p 589)

The palliative methods of treatment of carcinoma of the œsophagus

are—intubation gastrostomy and irradiation In many instances the patient when first examined is so sunken in health and strength that intervention of any kind may be ill judged this comment applies especially to gastrostomy

Intubation.—This method is especially valuable when the disease is in the mid part of the œsophagus and in suitable cases it brings much relief and may prolong life Tubes of rubber, gum-elastic, and metal have been advised The most satisfactory one, perfected by Soutter, is a flexible tube of German silver wire wound in a close spiral and fluted to assist in maintaining it in position

The stricture is first dilated by bougies introduced through an œsophagoscope and the tube is then inserted under direct vision In favourable cases it allows fluids and semi-solids to be swallowed without pain or difficulty and it may remain in place for several weeks or months If it should slip through the stricture and reach the stomach a larger tube may be inserted to replace it

Gastrostomy—This palliative operation is indicated especially if severe dysphagia occurs rapidly at a stage when the disease is still of limited extent It should not be advised when the disease is far advanced and in patients debilitated by starvation and cachexia for in such circumstances it is badly tolerated and often leads to early death while at the best it affords but little prolongation of life

The operation may be performed under local anæsthesia A short vertical incision is made an inch or so to the left of the midline and as high in the epigastrium as possible The rectus muscle is generally split in the line of its fibres and the peritoneum incised The stomach, which is always small empty and situated high up under cover of the left lobe of the liver is drawn downwards towards the wound. The most suitable site for the opening is in the anterior wall about 3 in. from the pylorus

In the method usually adopted (Senn) a tube is inserted and the stomach wall invaginated by concentric purse-string sutures after the manner of an inkwell. The purse-string sutures are introduced first Fine catgut is generally used and two or three sutures are inserted the innermost one forming a circle about 2 cm in diameter The stomach wall within the circle is then picked up and incised It may be noted that since the stomach is contracted its wall is very thick, and that the mucous membrane is but loosely attached to the outer coats and must be picked up and incised separately It is easy to make the mistake of incising only the outer coats and forcing the tube into the submucous layer When the lumen has been opened a rubber tube about 8 mm diameter or a No. 14 catheter is introduced and fixed to the edge of the stomach opening by a single stitch. The purse-strings are then tied in succession. The stomach is anchored to the anterior abdominal wall by two or three catgut stitches passed through the seromuscular coats and the parietal peritoneum. Finally the wound in the abdominal wall is closed round the tube

An alternative method of embedding the tube in the stomach wall is by the method of Witzel, similar to that used for enterostomy (Fig 293)

A third method especially suitable where the gastrostomy is likely to be maintained for a long time is the method of Janeway (Fig 221) Two parallel incisions 3 cm apart are made across the body of the stomach from curvature to curvature The intervening strip of stomach wall is freed at the lesser curve turned forwards and fashioned into

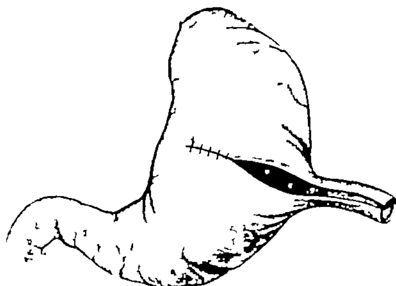


Fig 221
Janeway's gastrostomy A segment of the anterior wall of the stomach has been reflected towards the greater curvature to form a tube

a tube which is then drawn through a stab wound and sutured to the skin The defect in the anterior gastric wall is readily closed by sutures

After gastrostomy careful dieting is necessary to avoid the risk of enteritis

Radiotherapy —Carcinoma of the œsophagus is sometimes surprisingly radiosensitive but the deep situation of the growth and its close proximity to the heart and great vessels make for difficulty in applying an adequate dosage of irradiation

The cavitary method may be used radium embedded in an œsophageal bougie or tube being placed in position within the lumen of the stricture Although occasional good results have been obtained there are obvious physical difficulties in the way of applying effective dosage by this method

External irradiation is consequently preferred by most radiotherapists Here again however there are difficulties From the physical point of view an adequate dose even at the great depth at which the œsophagus is situated can be built up by the use of multiple ports of entry but it involves exposing a large volume of tissue—and the heart and great vessels with their contained blood—to massive doses of irradiation and as a result the general condition of the patient may suffer considerable deterioration.

Radical Operation.—The earliest successful operations for carcinoma of the œsophagus were carried out on the lines devised by Thorek After the tumour had been excised through the left pleural cavity the distal end of the œsophagus was invaginated and the proximal end was

tied and at the close of operation was exposed at the root of the neck and delivered into the wound and buried subcutaneously leaving a fistula on the front of the thorax For feeding the upper cut end of the œsophagus was connected to the gastrostomy by a rubber tube At a later period various plastic procedures using skin tubes or even the stomach itself or a loop of jejunum were evolved to construct an artificial passage under the skin to connect the œsophagus and stomach A freed loop of jejunum proved most valuable for this purpose There were so many difficulties and disadvantages (especially leakage) associated with these methods that they have been almost given up

Nowadays the aim is to bring the fundus of the stomach or a segment of jejunum (Roux fashion) through the diaphragm and join it immediately to the œsophagus no matter at what level the œsophagus has been divided (See also p 589)

If dysphagia has been severe and prolonged many surgeons prefer to carry out jejunostomy for a short period of feeding This preliminary step has the advantage of allowing exploration of the liver and the cœliac glands for metastasis The patient may thus sometimes be saved a wide exploration of the thorax Most surgeons however prefer if at all possible to avoid preliminary opening of the abdomen and to carry out a thoracic abdominal exploration at the outset and this is certainly the method of choice provided there is no obvious extra hazard

Usually the œsophagus is explored through the left pleural cavity after resection of the seventh or eighth rib The incision is extended if necessary on to the abdominal wall and the costal margin is divided. If removal of the tumour seems feasible the presence of abdominal metastases should be excluded by direct inspection after wide division of the diaphragm from the hiatus to the costal margin The œsophagus and the tumour are mobilised after division of the mediastinal pleura the vagus nerves are sacrificed Inflammatory fixation of the œsophagus to the mediastinum aorta or even the vertebræ is encountered in many instances

The subsequent technical manœuvres vary according to the level of the tumour If the tumour is in the lower third of the œsophagus the affected segment is excised and the distal end of the œsophagus is invaginated into the stomach and, thereafter the proximal end of the œsophagus is implanted into the fundus of the stomach already brought through the diaphragm If the cardia itself is involved a portion of the stomach will require to be mobilised to permit of resection When the tumour is situated at the level of the aortic arch—the commonest and most difficult site—the œsophagus must be mobilised both above and below the arch of the aorta In addition it is necessary to mobilise the proximal half of the stomach by division of its mesenteries and sometimes by removing the spleen so that the stomach can be brought to any level in the thorax for anastomosis with the divided œsophagus The method of suture and the materials employed vary in individual practice Usually three layers of silk sutures are used, and most workers insist that careful suture of the mucous layers is a safeguard against leakage At the close of operation the diaphragm is sutured carefully

and the stomach anchored at several places to the mediastinum and the pleura The pleura is drained Some insist that no fluid be given by mouth for three to four days after operation others adopt the opposite practice Apart from respiratory complications the commonest and most disappointing complication is delayed leakage at the stoma as a result of necrosis In cases which survive peptic ulceration from regurgitation may be a distressing complication it is difficult to treat satisfactory and it sometimes leads to stenosis

CARDIOSPASM ACHALASIA OF THE ŒSOPHAGUS

The obstruction in cardiospasm is of a functional character and is situated at the level at which the œsophagus traverses the diaphragm A barium swallow followed by screening and X ray films outlines the dilatation and other alterations (such as elongation or kinking) of the œsophagus Sometimes in older subjects it is difficult to decide radiologically whether a simple stricture or carcinoma of the œsophagus is responsible for the dilatation and obstruction Œsophagoscopy conducted under local anæsthesia will usually settle any doubt In cardiospasm it is safer to carry out œsophagoscopy under local anæsthesia because under general anæsthesia the retained contents of the œsophagus may regurgitate into the upper air passages

Medical measures such as giving antispasmodic drugs fail in the treatment of cardiospasm A variety of methods has been devised to overcome the obstruction they are not all of equal value a comment on each follows —

Hurst first employed a mercury loaded stomach tube to act as a bougie It should be passed under view using a fluoroscopic screen. It usually, though not always navigates the constriction and enters the stomach Sometimes it curls up within the dilated œsophagus and passage is impossible Even though the mercury tube passes

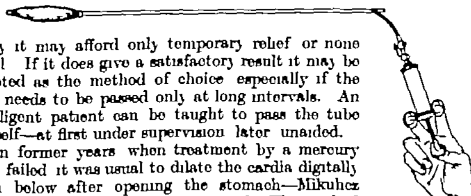


Fig 222 Hydrostatic dilator of Negus pattern as used in the treatment of Cardiospasm.

freely it may afford only temporary relief or none at all If it does give a satisfactory result it may be adopted as the method of choice especially if the tube needs to be passed only at long intervals. An intelligent patient can be taught to pass the tube himself—at first under supervision later unaided.

In former years when treatment by a mercury tube failed it was usual to dilate the cardia digitally from below after opening the stomach—Mikulicz operation It did not always succeed The method has fallen into permanent disuse

The present day preference is for endoscopic dilatation The hydrostatic dilator perfected by Negus is favoured by most operators (Fig 222) An œsophagoscope is passed the œsophageal contents emptied and the cardia sought and dilated by a gum elastic bougie The stilet of the hydrostatic bag is then passed into the stomach as a guide

for the dilator which should be adjusted to sit evenly within the cardia The bag is inflated with water to produce even dilatation of the lower end of the œsophagus The manœuvre is repeated at such intervals as may be required quite often one dilatation suffices In all but a few the method succeeds

In those instances in which dilatation fails the operation devised by Heller usually succeeds It entails longitudinal division of the muscular fibres of the lower end of the œsophagus over a distance of about 1½ in and also over a portion of the stomach wall Some prefer to carry out the division through a high abdominal incision but exploration through the thorax affords a clearer view and is technically more simple

The operation of œsophago-gastrostomy was at one time employed for the relief of cardiospasm Nowadays the need for it must be extremely rare Even though it may relieve the obstruction considerable distress from regurgitation of gastric contents may follow and subsequent stenosis may ensue

Sympathetic neurectomy for the relief of cardiospasm has been attempted, but permanent relief has not been secured by this method

FIBROUS STRICTURE OF THE ŒSOPHAGUS

Apart from injuries (as by instrumentation and foreign bodies) a fibrous stricture of the œsophagus may result from ulceration caused by corrosive fluids swallowed accidently or by design The condition is always serious and may be exceedingly difficult to treat successfully The stricture may be at any level but is commonest in the middle and lower third of the œsophagus The stricture is often multiple long narrow and tortuous The only other common cause of stricture is the cicatrization which may follow healing of a chronic peptic ulcer of the lower third of the œsophagus A stricture sometimes develops at the stoma following œsophago-gastrectomy X ray pictures after a barium swallow give the best information about the nature number and site of stricture

Treatment should be started as soon as possible after the ulceration has healed. Gastrostomy is often advisable both to maintain the nutrition and to facilitate dilatation of the stricture

In the first instance fine bougies should be introduced under direct vision through an œsophagoscope and the channel must be kept patent by regular dilatation at intervals of a few weeks After an adequate passage has been secured an intelligent patient may be provided with a soft gum-elastic bougie of suitable size and can be taught to pass it himself

In severe cases retrograde dilatation may be advised as being less likely to inflict injury Preliminary gastrostomy is necessary Swallowed thread is secured by a hook inserted into the stomach and is brought out of the wound A flexible gum-elastic bougie is then threaded over its lower end and introduced into the œsophagus from below

If dilatation of the stricture is impracticable owing to its length and narrowness a temporising gastrostomy is necessary In a young subject and particularly if the stricture is so impermeable as to interfere with the swallowing of saliva it may be justifiable to resect the affected portion of the œsophagus within the chest and to implant the proximal end into stomach on the same lines described for the operative treatment of carcinoma An alternative though less satisfactory method is to bypass the stricture by the creation of an ante-thoracic œsophagus To accomplish this the upper end of the œsophagus is delivered from the neck and is embedded subcutaneously on the front of the chest and later a long isolated loop of jejunum is used to connect the œsophagus to the stomach Tubes of skin have been used for the same purpose but on account of leakage and intractable itch which may follow are less satisfactory

Nowadays an œsophago jejunal anastomosis planned as for resection of carcinoma may be preferable

Congenital Atresia of the Œsophagus and Tracheo-œsophageal Fistula —Until recent years this defect was incompatible with survival The commonest variety is one in which the proximal part of the œsophagus ends as a blind pouch in the upper mediastinum and the distal part of the œsophagus communicates by a fistula at or about the bifurcation of the trachea

If the abnormality can be recognised in the first few days of life it may be possible to close the fistula and to reconstitute the œsophagus by end to-end suture The operation is usually done extrapleurally and on the right side Obviously expert care by pediatricians and nurses of premature babies is an essential part of the care of such fragile subjects

B M. D

REFERENCES

Dunhill, Sir T (1950) Pharyngeal Diverticulum." *Brit. J Surg.*, **37** 404
Garlock, J H (1947). "Technical Problems in the Surgical Treatment of Carcinoma of the Œsophagus and Stomach *J thorac. Surg* **16**, 215.
Lahey F H (1946). "Pharyngo-Œsophageal Diverticulum. *Ann Surg.*, **124**, 617
Ladd N E., and Swanson O (1947). "Œsophageal Atresia and Œsophageal Fistula." *Ann. Surg.*, **125**, 23.
Levin N M (1940). Teaching the Laryngectomised Patient to Talk. *Arch. Otolaryng.*, **32**, 299
Shallow T A. and Clerk, L. H. (1948). "Pharyngeal Diverticulectomy" *Surg Gynec. & Obstet.* **86**, 317
Wookey H. (1947-48) "Surgical Treatment of Carcinoma of the Hypopharynx and Œsophagus. *Brit J Surg.*, **35**, 249
Wooler, G H (1948) "Cardiospasm." *Thorax* 3, 88.

Fluctuation appears late A *premammary abscess* gives less constitutional upset and appears as a localised abscess under the skin covering the breast and fluctuation appears early A *retromammary abscess* pushes the whole breast forwards producing little deformity or discoloration of the breast and it points eventually in the inframammary fold

Operation for Breast Abscess.—When the abscess has formed, it may still be possible to avoid incision The abscess may be aspirated with a large-bore needle and 100 000 units of penicillin in 2 c c of water injected This procedure may require to be repeated two or three times on alternate days If the abscess enlarges or fails to subside with this treatment incision is required. Delay in the making of the incision is usually an advantage for the abscess will become more localised and healing subsequently will be more rapid

For opening a breast abscess general anæsthesia is necessary preferably gas and oxygen or intravenous pentothal

INTRAMAMMARY ABSCESS —The incision should be made over the point of maximum fluctuation, which usually corresponds to the most tender point on the breast The incision radiates from the nipple and should avoid the areola After the abscess has been opened the gloved finger is passed into the cavity and any loculi broken down If the abscess is large and particularly if the incision has been made above the nipple level, a counter incision should be made into the most dependent part of the abscess cavity (Fig 223) This is done conveniently by passing a hæmostat into the cavity projecting it under the skin at a suitable place and making a second incision over its point A rubber drain is then drawn in and through and through drainage instituted The incisions should be large so as to give easy exit for the pus and to allow for the shrinkage which occurs when the swelling of the breast diminishes If the abscess has been well localised a dry dressing is sufficient to absorb the discharge If there is much induration the application of heat by hot fomentations is continued The drain should be removed in the course of two or three days If the operation has been properly timed and the incisions are of adequate size the wounds should heal without delay Premature operation on the other hand and ineffective drainage may lead to residual mastitis with persistently discharging sinuses and necessitate wedge resection of the affected portion of the gland at a later date



FIG. 223

Breast abscess. Drainage tube being brought through a counter incision.

PREMAMMARY ABSCESS —A radial incision is made into the abscess and the pus evacuated A finger is then inserted to determine if there is a collar-stud cavity communicating with an abscess in the mammary gland If so the track must be enlarged either by stretching with a forceps or if the neck is narrow by incising it with the knife

RETROMAMMARY ABSCESS —The abscess tends to point in the

inframammary fold, and the incision to drain the abscess is made in the line of the fold The finger is passed into the cavity and a careful search made for a cavity within the breast tissue If such a cavity is found the opening into it must be enlarged so as to give easy exit to the pus

An acute retromammary abscess arising from the breast is a rare condition More frequently such an abscess arises as an acute infection in a rib X ray examination will not help in the diagnosis at this early stage as no changes are usually seen until much later When the abscess is opened the finger is passed into the cavity and a search is made for a bare area on one of the ribs which is evidence of acute osteomyelitis

A chronic retromammary abscess arises usually from a tuberculous infection of a rib or more rarely from a vertebra X ray examination will help in deciding the position of the primary lesion. Treatment will be for the primary lesion the cold abscess being treated as described on p 205

CHRONIC MASTITIS

In young women with the lobular type of chronic mastitis often affecting both breasts there is little risk of malignancy and the treatment should be conservative

A belladonna plaster may be applied or the breasts may be supported by adhesive plaster strips These should be applied from below the breast as far up as the clavicle with the patient in the recumbent position

Treatment by hormone therapy may yield satisfactory results Hexoestrol or dienoestrol (5 mg t.i d on the 18th 19th 20th and 21st day of the cycle counting the first day of the period as the first day of the cycle)

X ray treatment may bring about an improvement and is sometimes useful for the relief of pain in the breast A tissue dose of 200 *r* units is given once a week for six weeks

As the patient is usually anxious about the condition it is advisable to reassure her that it is not due to the presence of a tumour

In elderly women the lobar type of chronic mastitis is more frequent and its differential diagnosis from carcinoma may be difficult For this reason, in patients over thirty five years of age all swellings of the breast should be treated by operation, and the specimen examined by a competent pathologist

If a single segment of the breast is affected, it may be removed by the method of wedge resection A radial incision is made over the affected part the incision passing through the skin and avoiding the areola The skin flaps are dissected back on each side until the affected portion of tissue is exposed freely A wedge-shaped portion of the breast containing the affected area is removed the apex of the wedge lying close to the nipple As the breast tissue is incised free hæmorrhage is encountered and the vessels must be caught and ligated. To prevent the formation of a hæmatoma the dead space is then obliterated by two or three tiers of deep interrupted catgut sutures a curved cutting

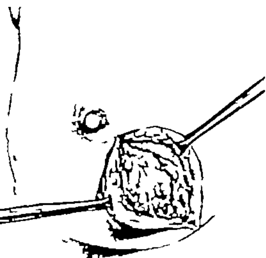


FIG. 224
Wedge resection of a portion of the breast showing the incision in the skin and dissection of the skin flaps.

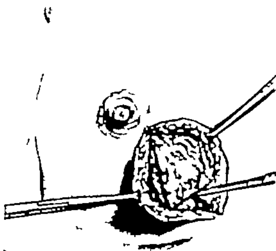


FIG. 225
The area of breast tissue to be excised.

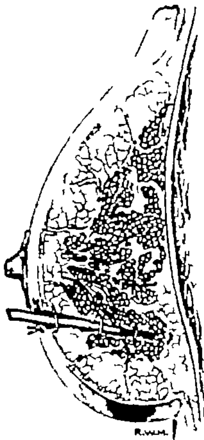


FIG. 226
Completion of the wedge resection, showing the buried sutures and the drain.

needle being used as the breast tissue is tough A rubber dam drain is then inserted between the stitches into the depths of the wound as a further safeguard against the formation of a hæmatoma The skin wound is then closed with the drain passing out between two of the stitches

If in elderly women the whole breast is affected the breast should be removed entirely An oblique elliptical incision is made including the nipple along with a portion of skin varying in size according to the size of the breast An ellipse of skin 3 in long by 1½ in wide at the nipple will usually be sufficient The skin edges are undercut and

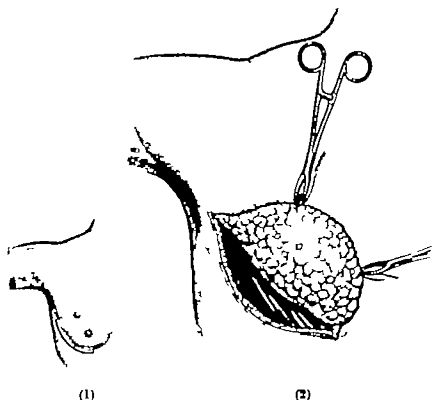


FIG 227

Removal of breast tumour by the Gaillard Thomas method.
(1) The incision. (2) The deep surface of the breast exposed.

retracted and the mammary gland is freed on its deep aspect from the deep fascia and removed. Vessels in the skin flaps and those entering the breast on its deep aspect are divided and must be caught and ligated Care must be taken that the axillary tail of the breast is removed lest a carcinoma develop there later

The wound is closed either by continuous or interrupted stitches a drainage tube being left in at the lower end and passing upwards for half the length of the wound The drain is removed at the end of three days and the stitches at the end of ten days

An alternative is by the *Gaillard Thomas method* The incision is made in the fold below the breast The breast is dissected off the chest wall and turned upwards a few small vessels requiring to be caught and ligated The whole mammary gland or a wedge including the

affected portion is then removed from the deep aspect The wound in the breast tissue is sutured with interrupted catgut sutures and the wound closed leaving in a drain This method has the advantage that the scar is not visible

SIMPLE TUMOURS OF THE BREAST

Pericanalicular Fibro-adenoma.—This type of tumour is met with in young women and it should be removed The operation is a simple one and the only difficulty is that the tumour, which is very mobile is sometimes hard to locate and identify among the mammary lobules *This is especially so if the tissues are infiltrated with local anæsthetic*, and accordingly general anæsthesia is preferable A useful method is to hold the breast between fingers and thumb in such a way as to project the tumour close under the skin and to keep it fixed there until it is exposed (Fig 228) A radial incision is made over the tumour and is deepened until the capsule is opened when the characteristic smooth appearance of the tumour will be seen The tumour can be shelled out with ease except at one point where the vessels entering it make it adhere to its capsule These vessels are caught and ligated The dead space from which the tumour has been removed is obliterated with interrupted catgut sutures and the skin wound closed, leaving in a rubber dam drain



FIG 228

Hard fibro-adenoma of the breast. The tumour is projected firmly under the skin while the incision is being made.

Intracanalicular Fibro-adenoma—In the early stages this tumour can sometimes be shelled out in the same way as the pericanalicular fibro-adenoma More usually, however it is necessary to carry out a wedge resection of the affected portion of the breast or even complete removal of the breast depending upon how much of the gland is affected.

IDIOPATHIC HYPERTROPHY OF THE BREASTS

Idiopathic hypertrophy of the breasts occurs in early adolescence and may become extreme The patient suffers inconvenience from the size and weight of the breasts and there may be considerable psychological upset The breasts are liable to severe infection

While removal of the breasts will rid the patient of the inconvenience and the risk of infection it usually has a harmful psychological effect Two types of operation have been devised The first consists of the removal of wedge-shaped pieces of breast tissue at each side thus reducing the size The second is by a specialised plastic procedure in which the nipple and areola freed from the surrounding skin but with their blood supply intact are transplanted to a higher level the lower two quadrants of the breast being then removed

CARCINOMA OF THE BREAST

Carcinoma of the breast may be treated either by surgery or by irradiation but the best results are to be obtained by a combination of both methods This demands the closest collaboration between the radiotherapist and the surgeon

At the present time the choice of treatment is primarily by surgery followed by irradiation

For the purpose of treatment it is usual to classify carcinoma of the breast into four stages *Stage I* where there is a mobile tumour in the breast with no clinical evidence of enlarged glands in the axilla or elsewhere *Stage II*, where there is a mobile tumour in the breast but where there are enlarged glands to be felt in the axilla *Stage III* where the tumour has become fixed to the chest wall with or without enlarged glands *Stage IV* where the disease is more advanced than in Stage III

In Stages I and II radical removal of the breast with a full course of post-operative irradiation will give results better than by surgery alone In Stage III there is no consensus of opinion some favouring removal of the breast with or without the axillary contents, followed by irradiation others trusting to irradiation alone In Stage IV it is found that no treatment will have any appreciable effect on the course of the disease

In Edinburgh the method of treatment has been simple mastectomy followed by a full course of irradiation The argument in favour of this method of treatment is that simple mastectomy removes the primary tumour which because of its bulk is not so readily affected by irradiation The laying open of the axilla in the radical operation tends to disseminate malignant cells If there are obvious enlarged glands on the medial wall of the axilla these should be removed at the time of operation By such a limited procedure only the gross evidence of the disease is removed, the microscopic spread of the tumour being dealt with by irradiation

In younger patients the production of an artificial menopause by irradiation of the ovaries has been found to improve the prognosis by diminishing the rate of growth of the malignant cells

Where a full course of radiotherapy is not available radical operation should be performed.

Post-operative Irradiation.—Irradiation by X rays should be advised as a routine after operations for carcinoma of the breast

The dosage is worked out so as to give 4,500 *r* units as a *minimal* dose over the course of three weeks The X ray treatment should be started about fourteen days after the operation when the wound has healed In order to ensure sound healing of the wound and thus avoid undue delay in instituting X ray treatment the surgeon should take care that the amount of premammary skin removed with the tumour is not so great as to necessitate suturing the skin flaps under tension The skin exposed to irradiation may require treatment as described on p 370

The Radical Operation.—The operation for the removal of a carcinoma of the breast conforms to the general principles of the

operative treatment of a malignant tumour for it is designed to remove the primary tumour a large area of healthy tissue round it the lymphatics which drain it and the regional lymph glands all in one piece *Thus at no stage in the operation should the line of spread of the tumour be cut across* The operation may be carried out in two ways by removing the breast first and the contents of the axilla last, or by dealing with the axilla first This latter method has the advantage that the more delicate dissection is completed first and that the large raw area on the chest wall is exposed for a shorter period of time

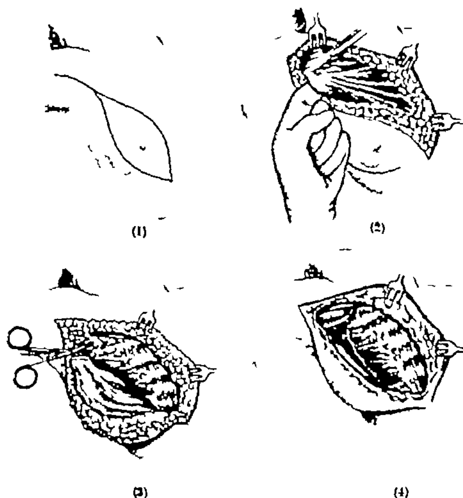
Position of the Patient —The patient lies on her back on the operating table with the affected side close to the side of the table The arm is supported in the abducted position either on an arm rest or by an assistant The arm should not be stretched upwards lest the nerves to the limb become contused

The principal steps of the operation are outlined but it will be found in practice that individual surgeons will vary the order in which they are carried out

The Incision —The incision starts over the insertion of the pectoralis major muscle sweeps over the front of the head of the humerus and passes downwards and medially almost to the xiphisternum Over the breast it splits to outline an ellipse which includes the nipple and the skin over the tumour Various modifications of the incision are necessary according to the position of the tumour The incision passes through the skin only The skin flaps are elevated until the midline is reached medially the clavicle superiorly and the posterior axillary line posteriorly Many vessels require to be caught and ligated in the skin flaps An area of superficial and deep fascia centred on the tumour and 8 or 10 in in diameter is thus outlined and will be removed with the breast

The pectoralis major near its insertion is now exposed, and the gap between its clavicular and sternocostal portions defined Deep in this space the branches of the acromio-thoracic artery are exposed and ligated in order to reduce the amount of bleeding in the later stages of the operation The sternocostal part of the muscle is now divided at its insertion turned downwards lifted off the chest wall and reflected along with the overlying breast The clavicular head of the muscle is usually preserved As the origin of the muscle from the sternum and ribs is cut through the perforating branches of the internal mammary artery are divided They should be held in hæmostats and not allowed to retract through the intercostal membrane The pectoralis minor now comes into view and is divided at its origin from the ribs and its insertion into the coracoid process and removed The large wound thus made is now covered over with hot wet towels to prevent loss of heat from the patient and the dissection of the axilla is commenced. Starting at the apex the fascia covering the axillary vessels is divided with the knife and by blunt and gauze dissection the axillary vein and artery are stripped of their lymphatics and fat The lymph gland at the apex of the axilla should be seen and removed while on the lateral side of the axillary vein a lymphatic cord may be seen A few small tributaries of the axillary vein require to be ligated and

divided Care must be taken not to pull any of these out (axillary vein for this will give rise to troublesome bleeding A dissection proceeds outwards and downwards the long thoracic will be seen on the side of the thorax This should be pres Farther laterally and behind the nerve to the subscapularis (th dorsal nerve) and the subscapular artery will be exposed lying (anterior surface of the subscapularis These should also be pres but the fatty tissue between and round them must be removed



(1) (2)

(3) (4)

Fig 229

Radical excision of breast. (1) The incision. (2) Sternocostal part of pectoralis m being freed and divided. (3) Apex of axilla being cleared. (4) The excision compl the axillary vein and the long thoracic nerve of Bell are seen.

dissection is now carried downwards and backwards until the fr of the latissimus dorsi muscle is identified and cleared The along with the area of fascia outlined the pectoral muscles a mass of tissue from the axilla are removed by dissection Any bleeding points should be carefully caught and ligated so as to le wound dry The wound is then closed and a rubber drainag inserted through the posterior skin flap to drain the axilla

Where much skin has been removed it may be difficult to cl wound without considerable tension Short superficial incisions n made parallel to the main one to reduce this tension or a ba

may be left and either covered at once by Thiersch grafts or allowed to granulate and later covered by pinch grafts Since recurrence of carcinoma in the skin can readily be prevented by X ray therapy it is no longer customary to remove a large ellipse of skin and consequently difficulty in closing the wound is rare

The patient is put back to bed with the arm supported comfortably on a pillow in the semi abducted position The patient is encouraged to use the arm after the first two or three days The drainage tube in the axilla should be removed at the end of three or four days and the stitches at the end of ten days

THE TREATMENT OF THE UNDIAGNOSED SWELLING OF THE BREAST

A patient may present herself with a small swelling in the breast whose nature it is impossible to diagnose Such a swelling may be a localised area of chronic mastitis or a tense cyst or a tumour either simple or malignant *It is wise in all such cases to acquaint the* patient of the difficulty of diagnosis and to advise operation which should comprise first a diagnostic incision into the tumour and secondly such extensive resection as then seems indicated.

The patient s permission should be obtained to proceed if necessary to the radical operation in view of the possibility of carcinoma full permission is usually accorded with readiness

The operation consists of making a simple incision into the swelling and then examining with the naked eye the appearance of the cut surface With practice a high degree of accuracy can be achieved on the following grounds —

(i) A *scirrhous carcinoma* gives a grating sensation when cut. It is said to cut like an unripe pear The cut surface becomes concave and the surface has a greyish colour There are *often little flecks of yellow to be seen scattered on the surface.* The tumour has no capsule

(ii) An encephaloid carcinoma cuts cleanly with the knife has a greyish surface which becomes convex *There is no capsule*

(iii) A simple tumour such as a fibro adenoma is homogeneous The cut surface becomes convex has a watered silk appearance and a capsule is seen

(iv) An area of chronic mastitis cuts cleanly having a rubbery consistence The surface is whitish and the cysts varying in size from that of a pin s head can be easily made out.

If facilities are available the doubtful area may be excised and frozen sections examined at the time by a pathologist used to this method If the condition should then prove to be simple it is removed by one of the methods described as appropriate through the incisions already made If the condition be malignant the raw surface is cauterised with pure carbolic and the wound closed with a continuous stitch The instruments and gloves are changed so as to prevent the risk of implantation of tumour cells The appropriate operation is then carried out

W A. D A.

CHAPTER XXVIII

AFFECTIONS OF THE THORAX

APART from dealing with injuries surgery of the thorax is concerned chiefly with the treatment of empyema, pulmonary suppuration tuberculosis intrathoracic tumours and diseases of the œsophagus and of the heart and great vessels

In the practice of chest surgery it is essential to have the finest modern equipment The anæsthetist and assistants should be specially trained and the service of a team of physiotherapists is indispensable It is preferable that a chest surgery department be within a rural hospital especially for the surgery of pulmonary tuberculosis and other chronic infections

Before embarking upon operations on the thoracic organs an exact topographical diagnosis should have been made Frontal and profile radiographs may provide all the information required but in many instances the examination requires to be supplemented by lipiodol radiographs by tomograph films and especially by bronchoscopy Lipiodol radiographs are obtained after instillation of lipiodol into the bronchi This is most readily performed by the oral or nasal route Three cubic centimetres of *decicaine* (1 per cent) are instilled into the nostril and allowed to percolate into the air passages the tongue being held forwards and the patient instructed to breathe deeply When anæsthesia is procured 10 to 20 c c of lipiodol are instilled into the same side of the nose and its passage to the lung awaited By altering the position of the patient by tilting him into different positions it is usually possible to outline the whole bronchial tree on the affected side

INJURIES AND WOUNDS OF THE CHEST

Non-penetrating Injuries.—Blows or crush injuries may cause damage to the chest wall and/or the viscera The commonest lesion is fracture of a single rib at the point of impact usually at the front of the chest This injury is treated very simply by adhesive strapping which should be applied during expiration, should extend 3 in. above and below the fracture and should encircle the chest The fracture heals rapidly and the plaster may be removed in three weeks

An alternative and effective method of treatment is to infiltrate the site of fracture with novocaine on one or more occasions and to encourage deep breathing from the outset The method has the advantage of safeguarding against respiratory infection and atelectasis

More severe crush injuries commonly cause fracture of several ribs posteriorly near their angles Often there is much respiratory distress with dyspnœa and cyanosis which may suggest visceral damage In the absence of such complications the treatment is to strap the chest as described above The risk of pneumonia should be combated by *propping the patient up by encouraging the expectoration of viscid* sputum and by prophylactic chemotherapy

In severe crush injuries of the chest (especially the so-called stove in chest) breathing may be severely hampered on account of the paradoxical respiratory movements It may be necessary to re-establish normal movement by nursing the patient in a Drinker s respirator

Subcutaneous emphysema is a common complication of such injuries It may extend to the neck and face producing much temporary disfigurement but though the crackling sensation annoys the patient there is no danger Spread of the emphysema may be controlled by adhesive strapping applied firmly across the root of the neck but no other treatment is required and the air is absorbed in a few days

In more severe injuries hæmothorax may occur (see p 483) Lastly *in rare cases the injury causes rupture of the lung heart or mediastinal* structures Such damage may occur even in the absence of demonstrable injury to the chest wall Simple rupture of the bronchus sometimes occurs and it may be repaired successfully at once or later

Penetrating and Traversing Wounds.—Wounds by stabbing or by bullets or other missiles are more dangerous They commonly give rise to pneumothorax (open, valvular or closed) to hæmothorax, *which may be complicated by superadded infection or to rapidly fatal* hæmorrhage from lungs heart or great vessels

Open Pneumothorax.—Here there is a free entrance and exit of air through the wound in the chest wall. If the wound is gaping air (often mixed with frothy blood) is expelled with a whistling noise on expiration and re-enters with a gurgle on inspiration. This injury constitutes a menace to life and requires immediate treatment In an emergency and especially if there is continued bleeding the wound should be plugged with antiseptic gauze and as soon as possible the wound edges should be cleansed and the defect in the chest wall made airtight by suture Sometimes the gap in the chest wall is too great to permit of suture *and then reliance must be placed on packing with* gauze and applying dressings which may be maintained in place with wide overlapping strips of adhesive plaster Extensive exploration of the chest in search of visceral injury is not justified while the patient is in a state of shock. In all cases air tight drainage should be adopted until lung expansion is complete and pl[illegible] on has ceased

Valvular or Ten[illegible] enters the pleural *cavity but cannot* [illegible] t from a ' suck ing wound of the [illegible] r only on inspira

and is motionless and tympanitic Death may occur rapidly if the air is not let out The immediate treatment is to insert a short wide-bore needle through an intercostal space to allow air to escape Later the needle may be replaced by a small catheter connected with a suction apparatus or led below the surface of a mildly antiseptic fluid which will act as a water seal.

Simple or Idiopathic Pneumothorax is of common occurrence and if the attacks are frequent it may cause great incapacity There may be no obvious underlying cause but quite often rupture of a single or multiple emphysematous bullae may be responsible The aim of treatment is to cause symphysis of the visceral and parietal pleura One method employed is to excite pleural reaction by painting both surfaces with a small quantity of 10 per cent of silver nitrate solution on one or more occasions The manœuvre is carried out under direct vision using a thoracoscope Considerable pain may follow and there may be a large effusion

An alternative method and one less harsh to the patient is insufflation of iodised talcum powder into the pleural cavity The application of powder may have to be repeated on two or three occasions The results of treatment are very satisfactory

Hæmothorax.—This is one of the commonest effects of chest wounds The bleeding may arise from the chest wall or from the lungs or both Pallor and collapse accompanied by an increasing area of dullness in the chest suggest progressive bleeding There may from encroachment on the lung be severe shortness of breath. Hæmoptysis suggests injury to the lung

The treatment of a large hæmothorax is an urgent matter All available methods of resuscitation including repeated blood transfusions may be necessary The blood in a recent hæmothorax does not clot at once on any considerable scale The blood should be removed completely before clotting occurs the belief that removal of the blood encourages fresh bleeding is fallacious

The blood of a recent hæmothorax should be removed completely by repeated aspiration at the lowest extremity of the pleura If aspiration is difficult as it may be after a few days, the blood can usually be removed easily through a trocar and cannula assisted by suction In neglected cases the visceral and parietal pleura become greatly thickened the lung is unable to expand, and the chest wall becomes contracted In these circumstances decortication of the lung by stripping and removal of the thickened visceral and parietal pleura is required, and the result is usually satisfactory

Superadded infection of a hæmothorax is less common since the introduction of penicillin The penicillin should be given intra muscularly and also by daily intrapleural injection of a million units in 20 c c saline If infection does supervene continued aspiration may suffice if the offending organism is sensitive to penicillin otherwise drainage followed by decortication may be required.

Foreign Bodies in the Chest.—Foreign bodies such as portions of clothing may be responsible for infection They may be encountered in the course of the operation for drainage

Bullets and shell fragments seldom cause urgent symptoms and may be left alone Their removal will be indicated if they are of large size or if they are responsible for repeated attacks of hæmoptysis persisting pain or are responsible for local suppuration

At operation when the pleural cavity is opened and the lung deflates the object can usually be detected without difficulty and can be removed through a small incision directly over it If the fragment has been present for a long period it will be enclosed within a capsule of dense scar tissue Bleeding from the lung is readily controlled by sutures At the conclusion of operation a million units of penicillin in saline are left in the pleural cavity as a safeguard against infection

ACUTE EMPYEMA

Empyema may complicate any type of pneumonia and occur at any age Its frequency and severity have been markedly reduced since the introduction and vigorous use of sulphonamide drugs and penicillin These agents too have simplified the plan and methods of treatment and have rid the disease of its serious features and most of its complications Yet from time to time neglected cases are encountered and the traditional methods of treatment have still to be adopted

Recognition of empyema by physical signs is usually simple but X ray examination is advisable to determine the size and position of the empyema and exploratory puncture should also be carried out to ascertain the character of the pus and the nature of the infecting organism The pathological and clinical features of empyema may differ according to the organism responsible In empyema of pneumococcal type the pus usually develops after the underlying pneumonia has subsided From an early stage the pus is thick and localised to one part of the pleura by the adhesion of the lung to the chest wall. Open drainage will not cause distress because deflation of the lung and displacement of the mediastinum are unlikely to be more than slight In empyema of streptococcal type the effusion often develops while the respiratory reserve is still greatly reduced and the volume of pus (usually thin) may be so great that the lung cannot adhere to the chest wall Drainage at this stage will produce an open pneumothorax and may cause a severe displacement of the mediastinal structures and embarrassment of the opposite lung Therefore drainage should be carried out by an airtight method or deferred until the pus becomes thick and localised

In all types of empyema the problems of treatment are to cut short the illness to provide adequate drainage without risk, and to make certain that the lung expands to obliterate the pleural space The method employed may have to be varied according to the particular features of the empyema

In the common type of fully established pneumococcal empyema in adults in which the pus is confined in the lower and back part of the chest free drainage by rib resection is necessary to ensure its complete evacuation with removal of all coagula and to afford an opportunity

for inspecting the local conditions within the chest In infants however and in gravely ill patients when the lung is collapsed and the mediastinum displaced by a large empyema, and in most cases of streptococcal empyema it is wise to avoid the possible consequences of an open pneumothorax by the minor procedure of closed (airtight) drainage which will usually tide the patient over a critical period and allow the lung partly to re-expand This method should not however be relied upon entirely to furnish adequate drainage and if there is evidence of its ineffectiveness rib resection should be performed when circumstances are propitious

As stated above the seriousness of pneumonia of all types and the gravity of its complications such as empyema have been reduced since the introduction of penicillin Indeed the plan and programme of treatment have been altered very radically When empyema is imminent penicillin should be given (at least a million units daily) intramuscularly The pus should be evacuated by aspiration every day or two and penicillin (50 000 units) introduced into the pleural cavity In pneumococcal empyema the pus will be sterilized within a week or so In children this will usually bring about cure especially if the empyema is localized In adults especially with a bulky empyema drainage may still be needed to remove the coagulated exudate (the so-called penicillin clotted-empyema) In streptococcal empyema of the usual type aspiration should be continued longer—say one to two weeks—until the exudate ceases to collect and/or the pleural space is obliterated In selected cases early drainage of pneumococcal empyema by rib resection and removal of coagula followed by wound closure followed by repeated instillation of penicillin avoids the need of drainage



Fig 230

Trocar and cannula with self-retaining catheter for closed drainage of empyema.

Methods of Drainage—(a) *Closed (Airtight) Drainage* is obtained by inserting a self retaining catheter of Malecot pattern by means of a moderate-sized trocar and cannula (⅜ in bore)

The tissues overlying the selected intercostal space are anæsthetised with a 1 per cent local anæsthetic and a small skin incision is made The trocar and cannula are inserted and after withdrawing the trocar the catheter is introduced into the cavity Since the pus is usually under slight pressure and will drip from the cannula there is no risk of open pneumothorax so that introduction of the catheter can be done leisurely When in place it should be controlled by a clip and later connected with a syphon-drainage system In large effusions the escape of pus should be regulated so that re-expansion of the lung gradually occurs

Drainage by this method is sometimes very satisfactory and may especially in children be sufficient to allow healing of the pleura Often however the tube becomes blocked with fibrin or from one or other cause suppuration is prolonged or leakage around the tube occurs When the method has served its immediate requirements—reduction of toxæmia and partial re-expansion of the lung—more adequate drainage may have to be obtained by rib *resection and it should not* be delayed too long

(*b*) *Drainage by Rib Resection*—The patient should lie on his sound side with the front of the chest supported although in severe cases and in children an almost supine position may have to be adopted To allow of gravitation of the pus the head of the operating table should be tilted upwards about 15 The operation is usually carried out *under local anæsthesia but in very nervous patients or young children* gas and oxygen or cyclopropane is preferable

It is important that the empyema be drained at its lowermost part otherwise there will remain an undrained pool of pus when the patient is nursed in the semi recumbent posture The lowermost level at which pus can be obtained by aspiration is the site selected for rib resection and in most cases it will be the eighth or ninth rib in front of its angle

A 2 in skin incision is made in the line of the rib and the latissimus dorsi is split There may be a good deal of bleeding from minor vessels. An exploring needle is then inserted to confirm the presence of pus The appropriate rib is then exposed and its periosteum stripped gently with a sharp raspatory About 2 in of bone are resected The deep periosteum and pleura are then pierced with a scalpel. The *pus is then evacu*ated preferably by suction to avoid soiling Large coagula of lymph that may impede drainage are removed with sponge-holding forceps.

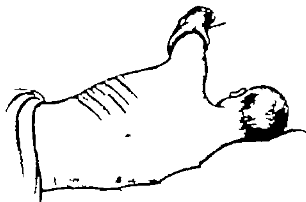


FIG 231
Acute empyema. The site for incision is indicated.

For drainage a large-bore firm rubber tube with a lateral opening is passed for 1½ in into the pleural cavity It is fixed to the skin either by suture or by sterilised string tied round it and anchored by strapping some distance from the wound More than light suture of the muscles should be avoided as it causes sloughing A couple of stitches of silk worm gut lightly close the skin This usually provides a water tight drainage *It is not intended to be nor does it need to be fully airtight*

The drainage tube is led via a glass connection and additional tubing to a Winchester bottle containing antiseptic fluid

In the after treatment no care should be spared in maintaining uninterrupted *drainage The surgeon should supervise* the details

himself Dressing on alternate days is usually enough Irrigation of the pleura is unnecessary (except to clear débris) if the drainage opening has been properly placed and the flow of pus is uninterrupted

Measures should be taken to restore the patient's strength and nursing in the fresh air is the most invigorating The patient should be encouraged to get up as soon as possible

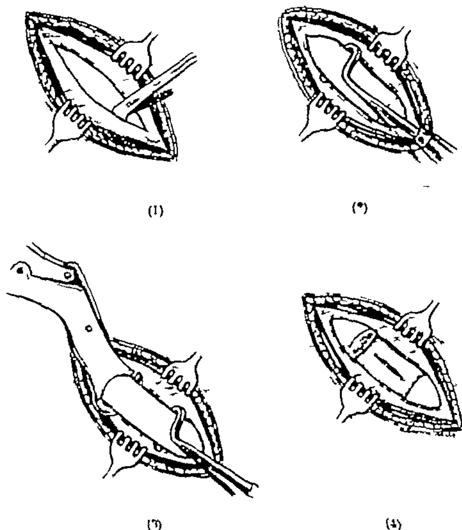


Fig 23*

Rib resection for acute empyema.

(1) Rib periosteum incised and elevated. (2) Doyen's rib raspatory used to elevate the deep periosteum. (3) Rib shears introduced. (4) Parietal pleura incised.

As convalescence proceeds the drainage tube will become loose in the wound It can be maintained in place by tapes and strapping The temptation to remove the tube should be resisted so long as a space remains in the pleura even though the *discharge is small* in amount because herein lies the all too frequent cause of continued suppuration

The original tube or one of smaller calibre should be retained until the lung has expanded and becomes glued to the chest wall

TUBERCULOUS EMPYEMA

This condition usually takes the form of a pyopneumothorax It may arise as a complication in the course of pneumothorax or other treatment or result from rupture of a tuberculous focus on the surface of the lung

The pneumothorax treatment should be stopped and the effusion treated by repeated aspiration, preferably using a large two-way syringe Given time the infection may subside the effusion become thinner and clearer and the lung may re-expand Delayed re-expansion of the lung may be partly overcome by crushing the phrenic nerve to relax the diaphragm

If however as is very common, obliteration of the pleural space does not occur within a short time there should be no delay in securing it by surgical means There is always a grave risk of superadded pyogenic infection a broncho-pleural fistula or sinus formation on the chest wall or all three combined

The choice of treatment depends on the local conditions present in the pleura and lung In some instances the tuberculous disease within the lung is quiescent and in such cases thoracoplasty done in stages may be effective in closing the empyema space If however there is persistent chronic infection with cavitation resection of the lung and infected pleura may be the only method of treatment likely to succeed (pleuro-pneumonectomy)

In some subjects the physical condition may preclude drastic surgical measures and external drainage only may be feasible The need for permanent tube drainage may be overcome by some form of plastic infolding of skin flaps at the site of a small thoracotomy wound.

BRONCHIECTASIS

In bronchiectasis while chemotherapy physiotherapy and broncho scopic aspiration are valuable palliative methods of treatment and may add greatly to the patient s comfort by reducing the quantity and the odour of the sputum they fail to bring permanent relief *In suitable* subjects surgical treatment is fully justified because it alone can cure the disease Surgical treatment entails removal of the diseased seg ments of the lung it may be one lobe (lobectomy) two lobes or sometimes the entire lung (pneumonectomy) Occasionally *one lobar* segment such as the lingula on the left side is affected alone it can be resected without sacrifice of adjacent segments When bronchiectasis is *bilateral* and especially if it is circumscribed it can be dealt with in two stages Improvements in technique have simplified the surgery of bronchiectasis nowadays there is practically no operative *mortality* and post-operative complications are unusual Unless there is some obvious contraindication operation can be *advised* at any age from 2 to 45 years or even later The more severe *the condition* the more gratifying is the result

The entire bronchial tree of each lung should be outlined by lipiodal radiographs taken on separate occasions lateral and oblique pictures are needed lest a diseased segment is overlooked On the left side the lingula of the upper lobe is affected in conjunction with the lower lobe in a high proportion of instances

Operation is specially indicated in those subjects in which the sputum is copious and/or of foul odour It is indicated too when there are recurring attacks of pneumonia due to retention of secretion within a collapsed portion of the lung Recurring hæmoptysis may be the chief indication for surgery

Before operation endeavours should be made by postural drainage and sometimes by penicillin instilled into the bronchi to reduce the quantity and infectivity of the sputum

Skilled anæsthesia is essential preferably by cyclopropane The trachea must be intubated and provision made to remove accumulations of sputum by suction If *sputum is very copious some anæsthetists* favour blocking the main bronchus of the diseased side by means of an inflatable bronchus blocker and then maintain respiration through the healthy lung During operation it is advisable to keep the *lung moderately buoyant and inflated as a safeguard against* subsequent atelectasis To overcome some of the difficulties associated with excessive sputum it is an advantage to carry out the operation with the patient in the face-downwards position with the thorax in a *position favouring natural drainage of secretions It favours access to* the hilar structures

In operating the pleural cavity is explored through an antero-lateral incision approximately in the line of the great fissure The sixth or *the seventh rib is resected The diseased lobe of the lung may be* quite free more often however there is adhesion to the chest diaphragm and to the lobe above and this may render its isolation difficult By painstaking dissection the individual structures of the *lobar hilum are displayed If there is copious sputum it is an advantage* to secure and divide the bronchus at an early stage The artery and the vein are secured separately The bronchus is usually closed by interrupted sutures of silk At the completion of operation drainage *is provided through a stab wound in the lowest intercostal space behind* the tube is led below the surface of an antiseptic fluid to form a water seal The tube is seldom needed for more than three or four days. The patient is usually able to be out of bed within a week children sooner

Post-operative empyema and bronchial fistula were formerly common Nowadays with the use of penicillin they are very uncommon

Occasionally there is delayed expansion of the remaining lobe of the lung This may be due to retained bronchial secretion bronchoscopy should be carried out forthwith and may need to be repeated From the outset the patient has breathing exercises under the super*vision of a physiotherapist*

If pneumonectomy is required for extensive bronchiectasis it is carried out on the same lines as for carcinoma (p 400) The only

lifficulty likely to be encountered in the dissection of the hilum is bleeding from enlarged lymph glands which may overlie the pulmonary artery and bronchus

LUNG ABSCESS

The common lung abscess is usually due to aspiration of infective material though its source is not always obvious The organisms responsible include pneumococci hæmolytic and non hæmolytic streptococci and mouth spirochætes.

The clinical features vary according to the type of suppuration and at the onset are like those of pneumonia, but the illness is often more severe and protracted As suppuration progresses the abscess burrows into the bronchi and its contents (usually putrid) are expelled by coughing Sometimes the abscess ruptures into the pleura and may lead to severe toxæmia and to fatal tension pneumothorax

An abscess may occur at any site in the lung but the commonest sites are the subapical segment of the upper lobe and the dorsal segment of the lower lobe

Formerly lung abscess was a grave illness and was associated with special difficulties in diagnosis localisation and treatment The mortality was at least 25 per cent

The problems of treatment have been greatly simplified since penicillin has come into general use Treatment should be started at the earliest moment and while the disease is in its pneumonic phase and before there has been much disorganisation of the lung The dosage of penicillin must be large not less than 2 million units per day In the majority of instances resolution is obvious within a few days and may be complete within a fortnight

In neglected cases of chronic abscess or in those in which penicillin has not been completely effective healing is unlikely on account of the disorganisation of the affected part of the lung In these circum stances lobectomy should be carried out as soon as possible

Formerly external drainage was employed for an established lung abscess The method was difficult technically and uncertain in its results It has now been given up in favour of resection

Spreading Suppurative Pneumonitis.—This form of suppuration is chronic from the onset and spreads gradually over a period of months to involve almost the entire lung which becomes the seat of multiple abscess cavities containing fœtid pus and sloughs It rarely responds to medical measures Pneumonectomy is the only means of treatment On account of the depleted condition of the patient and the special technical difficulties there is a considerable mortality

SURGICAL TREATMENT IN PULMONARY TUBERCULOSIS

In pulmonary tuberculosis surgical treatment should be considered when the disease in the lung remains active or progressive in spite of rest and sanatorium treatment and especially if cavitation is present

The aim of surgical treatment is to afford rest and relaxation in the lung to favour healing The methods, of which there is a wide

choice, are known collectively as "collapse therapy" However during the past few years there has been a growing tendency to excise the diseased portion of lung or to remove the entire lung and for some types of disease it is the method of choice Surgical methods have their greatest value when the disease is confined to one lung but many cases of bilateral disease are within the range of successful treatment

Streptomycin has made surgical treatment possible at an earlier stage in a greater number of cases and on a bolder scale In addition it affords a safeguard against the spread of disease during the active stages of surgical treatment especially in the immediate post-operative period

The choice of method and the time for its adoption will depend on the type and stage of the disease The chief methods of treatment are (1) *Artificial* pneumothorax often supplemented by adhesion section (2) phrenic nerve crush usually combined with pneumoperitoneum (3) extrapleural pneumothorax (4) thoracoplasty (5) pulmonary resection—segmental lobar or total A brief description of the scope and technique of each procedure will suffice

1 **Artificial Pneumothorax.**—*This was the earliest and the most* universally used method of collapse It has gradually lost its popularity chiefly because it is so frequently ineffective has certain hazards, and commits the patient to a protracted term of active treatment The chief use of artificial pneumothorax is for subacute cases (exudative) in which the disease remains indolent in spite of rest and especially if cavitation persists Artificial pneumothorax should be avoided when the disease is very acute and active on account of the risk of producing *a large pleural effusion Sometimes artificial pneumothorax treatment* has to be abandoned at an early stage because a cavity persists or increases in size (tension cavity) or because part of the lung remains atelectatic as a result of tracheo-bronchial ulceration

The technical details of the induction and maintenance of artificial pneumothorax are dealt with fully in textbooks of tuberculosis

One of the chief obstacles to effective collapse by artificial pneumothorax is pleural adhesions which prevent control of diseased portions of the lung—*especially cavities Intrapleural division of adhesions through* a thoracoscope may succeed in perfecting the collapse The X ray film will suggest the position and nature of the adhesions and the extent to which they limit collapse and direct inspection through the thoracoscope will determine the feasibility of their division The operation done under local anæsthesia (2 per cent metacaine) does not upset the patient and is without particular risk. The thoracoscope (telescope) is passed via a cannula through the fifth intercostal space posteriorly and a general *view of the pleural* cavity obtained A cautery electrode is now inserted by a trocar and cannula through an intercostal space in the mid axilla or the front of the chest (Fig 233) It is directed under vision and division effected with *the* cautery *at a dull red glow* When the adhesions are in the proximity to large blood vessels or when they overlie cavities great care should be observed to avoid hæmorrhage or leakage of infection

It is dangerous to divide a stout adhesion which overlies a large peripheral tension cavity Subsequent necrosis may lead to tension pneumothorax leakage of infection and empyema

2 **Phrenic Nerve Crush (and Pneumoperitoneum)** —Phrenicectomy is seldom used as an independent measure It is sometimes employed as a palliative for hæmoptysis harassing cough, vomiting or pain due to diaphragmatic adhesions

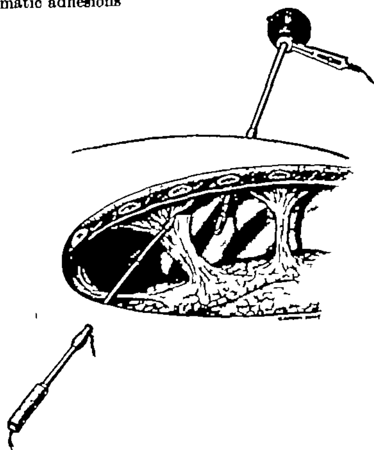


Fig 233

Division of pleural adhesions. The adhesion is being divided by cautery under direct vision through the thoracoscope.

Crushing of the phrenic nerve is employed very frequently in conjunction with pneumoperitoneum The resulting rise of the paralysed diaphragm may be considerable and the collapse of the diseased lung very satisfactory The method is very commonly adopted as a preliminary method of treatment of disease with cavitation in the middle and lower zones of the lung and by many is preferred to artificial pneumothorax especially if the disease is in an active and acute phase In some instances it brings about complete healing if healing is incomplete the disease is usually reduced in extent and activity and is rendered more suitable and safe for more major procedures

The operation of phrenic crush is carried out under local anæsthesia (2 per cent metacaine) and the nerve is sought at the root of the neck where it crosses obliquely beneath the fascia on the surface of the scalenus anterior muscle (Fig 234) A transverse incision is made through the skin at the outer border of the sternomastoid muscle and

is deepened through the fascia and fat of the posterior triangle The sternomastoid muscle is retracted medially along with the internal jugular vein The transverse cervical artery crosses tortuously over the scalenus anterior muscle in front of the phrenic nerve and may be a useful landmark The nerve is usually easily found as it crosses very obliquely from the lateral border of the scalenus muscle At the time of crushing there may be sharp pain Paralysis of the diaphragm usually persists for about six months the operation may need to be repeated

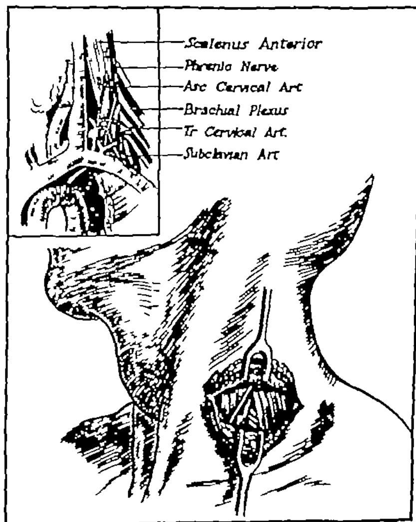


FIG. 234
The anatomical relations and exposure of the left phrenic nerve.

Pneumoperitoneum is often of value in the initial stages of treatment of bilateral disease It is of special value and safety in the treatment of very active and acute disease

Pneumoperitoneum is induced and conducted on similar lines to pneumothorax 500 c c of air are inserted into the upper abdomen at the induction followed by additional quantities on alternate days until the optimum elevation of the diaphragm is secured Finally refills of about 1 000 c c of air are given weekly The duration of

treatment depends on the response of the disease but need not be so protracted as pneumothorax more often than not the treatment is a preliminary to a more radical measure Mediastinal emphysema and peritoneal effusion are occasional complications of pneumoperitoneum

3 **Extrapleural Pneumothorax.**—This method of collapse was for a time popular some fifteen years ago It gave good results but was discarded by all but a few on account of the complications of hæmorrhage and infection—pyogenic and tuberculous Now it has been revived and adopted widely as a result of the protection afforded by penicillin and streptomycin administered locally and parenterally It is a selective form of collapse valuable especially in cavernous disease of the upper lobe of the lung and particularly in those instances in which simpler forms of collapse have failed or are unfeasible It is a useful substitute for thoracoplasty though it does not entirely replace it It has the advantage that it can be performed in subjects under 17 years of age and in elderly subjects too fragile for thoracoplasty In selected cases it can be employed for bilateral disease of the upper lobe of the lung

The operation is fairly standardised A short paravertebral incision is made to expose the outer surface of the fourth rib posteriorly About 4 in. of the rib are resected subperiosteally By gauze pressure the parietal pleura is eased from the chest wall concentrically until sufficient space is made for the insertion of a Tuffier rib spreader Under vision with suitable illumination the pleura and lung are stripped from the apex mediastinum and dorsal part of the chest to a level at least as low as the lung hilum The space created is voluminous and following closure of the wound is filled with saline streptomycin and penicillin (about 20 oz in all) The day following the fluid (with blood clot) is aspirated as completely as possible and the antibiotics replaced together with sufficient air under pressure to maintain optimum lung collapse During the ensuing days aspiration may need to be repeated on several occasions The X ray screen appearances are the guide to the extent it is required and also as to the amount of air refilling Usually within ten days the pneumothorax space is dry and of the size desired Refills of air are usually done weekly the pressure requirements are usually of a high positive scale seldom below 10/25

In a few instances reactionary hæmorrhage occurs with extensive clotting This may after a fortnight necessitate reopening of the wound to evacuate the clot It need not vitiate the final result indeed the temporary collapse by effusion sometimes enhances the quality of the pneumothorax

Failure to bring about cavity closure is unusual when it occurs thoracoplasty may finally be required.

4 **Thoracoplasty** is reserved for certain types of chronic tuberculous disease when less severe measures are impracticable or have proved unsuitable from one or other cause The case will usually be one in which there is extensive shrinkage and fibrosis with a single or multiple cavities and widespread pleural adhesion indeed the disease will have reached a stage at which no other method except rib resection or pneumonectomy will effect cure Before operation is attempted it

should be known that the opposite lung is healthy or disease in it is controlled and that the patient is sufficiently robust to bear the turmoil of a major surgical intervention

Tomograph films of the affected lung are of particular value in defining the number size and position of cavities The evidence they provide will guide the surgeon in planning the extent of rib resection and lung mobilisation In circumscribed disease (usually in the upper lobe) resection of four or five ribs may suffice but when the disease is more widespread seven or more may have to be sacrificed

In many instances bronchoscopy should be carried out before operation is contemplated to exclude the presence of extensive tracheo-bronchial ulceration If such is present thoracoplasty may be ill advised unless the ulceration yields to treatment by streptomycin It is generally held that persisting ulceration is a definite contraindication to thoracoplasty collapse

Thoracoplasty is no longer a standard and set manœuvre rather the number of ribs and the amount of each to be removed are adapted to the extent and character of the disease The trend in recent years has been to be as conservative as possible and to rely on concentric mobilisation and fixation of the lung rather than on extensive sacrifice of ribs The type of operation favoured in most countries is modelled on that described by Carl Semb It has been modified in detail by the originator himself and by individual workers In all but a few instances it is performed in two stages It is well borne and the early mortality very slight (say 2 per cent)

To protect the patient against spread of infection to the opposite lung in the immediate post-operative period it is usual to give the patient streptomycin for a week before and for two weeks after operation

The best anæsthetic is cyclopropane preceded by intravenous injection of pentothal sodium although local anæsthesia is favoured by many operators The use of curare to secure muscular relaxation has been a distinct technical advance

At the first stage of thoracoplasty the upper ribs are exposed through a long paravertebral incision curved slightly at the lower extremity The incision extends from the level of the superior angle of the scapula to below its inferior angle After division of the trapezius and rhomboid muscles the upper ribs come into view partly covered by the digitations of the serratus posterior superior the erector spinæ and the scalenus posterior When the scapula is retracted upwards and outwards the digitations of the serratus anterior come into full view The muscle is divided close to the ribs to increase access and to open up the back of the axilla When the ribs are cleared of muscle resection begins starting with the third or fourth followed by the second and first The aim is in all cases to remove practically the entire first and second ribs Resection of the first rib is done by first baring its outer border of periosteum from back to front the under surface of the rib is then stripped subperiosteally with a broad rongeur to free the inter costal muscles This done the entire inner border of the rib comes into view It is stripped from behind forwards with a bifurcated

stripper Finally the muscles on the superior surface of the rib—chiefly the scalenus anterior and medius—are detached subperiosteally The rib is divided under full vision both behind and in front Next a portion of the transverse process of the first and second thoracic vertebræ is removed The next important step is to carry out a concentric mobilisation of the upper lobe of the lung (apicolysis) The endothoracic fascia is usually more conspicuous in tuberculosis of the lung and a ready plane of cleavage can be secured to permit of extra fascial stripping of all faces of the lung only occasionally is sharp dissection required After stripping which may have to be carried almost to the hilum of the lung a liberal view of the subclavian artery the lower part of the brachial plexus and the innominate vein etc is obtained. The space created (sometimes called Semb s space) is of considerable size Before the wound is closed completely 10 c c of penicillin (a million units) should be left in the space as a protection against infection

The second stage of the thoracoplasty is done as soon as possible usually within ten to fourteen days It entails wide resection of the lower ribs sometimes as far as the seventh to the tenth according to the individual requirements of the case

To overcome the tendency of the lung to re-expand during the early weeks of convalescence it may be helpful if the extrafascial space is filled periodically with air

The most disturbing complication of thoracoplasty is atelectasis of the lower lobe of the lung after the first stage When it occurs every effort must be made to dislodge the tenacious sputum from the bronchial passages Bronchoscopic suction is the most effective method.

After thoracoplasty the patient should be put under the care of a physiotherapist who will by exercises train him to avoid faulty postures which predispose to scoliosis drooping of the shoulder girdle and reduction of arm movement It is usual to keep the patient totally in bed for some two months after which he gradually resumes full activity

In a large series of thoracoplasty operations the early death rate from operation is under 3 per cent In about 70 per cent of instances tubercle bacilli finally disappear from the sputum

5 **Lung Resection.**—There are certain forms of pulmonary tuberculosis which cannot be treated successfully by the orthodox methods of collapse It is in these that lobectomy or pneumonectomy offers the only prospect of eradicating the disease This method would seem to offer the ideal solution to many difficult problems but unfortunately it is beset with *certain pitfalls* The use of streptomycin has reduced considerably a major risk—rapid spread of disease within the opposite lung and the early development of a bronchial fistula and tuberculous empyema

There is not unanimity of opinion as to the type of case which should be submitted to resection but it is generally agreed that the following types are suitable (1) A caseous tuberculoma (2) a completely derelict lung the seat of multiple cavities (3) tuberculous bronchiectasis associated with bronchostenosis (4) tuberculous

tracheobronchitis which has been carefully controlled by *streptomycin* (5) cavitation which persists after thoracoplasty and (6) some cases of persistent cavitation in the dorsal segment of the lower lobe

Pneumonectomy is usually the method of choice but the decision can sometimes only be reached at exploration Technically the operation is usually more difficult than resection for bronchiectasis on account of widespread ligneous adhesions therefore in many instances it is necessary to remove the lung and pleura *in toto* (pleuropneumonectomy) Apart from the occurrence of the disease spreading to the opposite lung there is a risk of a bronchial fistula and empyema due to undetected ulceration at the site of suture These complications are getting fewer with growing experience Many operators perform thoracoplasty as a routine following pneumonectomy it would seem to reduce the incidence of fistula and empyema and if they do occur their gravity is lessened

INTRATHORACIC TUMOURS

Intrathoracic tumours occur in two chief sites—the mediastinum and in the lung and bronchial passages

Mediastinal Tumours are usually simple and occur in young subjects the commonest varieties are dermoid and other congenital cysts and neurofibroma (especially ganglioneuroma) They grow slowly but may assume great bulk and may cause serious pressure on the trachea the great vessels and nerve roots

Removal of a mediastinal tumour is called for if there are pressure symptoms especially if there is increasing dyspnoea The operation is conducted through the standard thoracotomy incision and the thorax is opened at a convenient level The tumour is covered by a capsule of pleura from which it must be enucleated If the base of attachment to the chest wall is broad and firm considerable care must be exercised to avoid injury to large vessels especially the azygos vein and the superior vena cava If there has been superadded infection with resulting dense adhesions total removal may be impossible and in such circumstances it may be wise to leave a portion of the fibrous wall of the cyst attached to any structure liable to injury

A Bronchial Adenoma is the only common simple tumour of the lung It may be responsible for recurring hæmoptysis atelectasis or infective complications It is commonest in the bronchus of the lower lobe of the lung and especially on the right side It may be confined to the lumen of the bronchus but more often the intrabronchial portion is connected by a stalk to a spherical mass within the lung tissue

A small adenoma (if not too sessile) confined to the lumen of the bronchus may be removed by nibbling forceps through a bronchoscope If however the tumour is bulky and especially if there is an extra bronchial extension thoracotomy is required At operation it may be possible to enucleate the intrapulmonary portion of the tumour and to excise the intrabronchial portion (bronchotomy) If the lung distal to the tumour is the seat of atelectasis or infection lobectomy will be necessary

Bronchial Carcinoma is the most important lung tumour and its incidence and malignancy is almost as high as that of carcinoma of the stomach It affects men more often than women in the proportion of at least 12 1 It is unfortunate that the disease is often far advanced either before there are notable symptoms or before advice is sought It is estimated that the disease lends itself to surgical removal when first seen in only 15 per cent of instances

From the clinical radiological and bronchoscopic appearances it is usually possible to decide with moderate accuracy those cases in which operation is likely to be accomplished successfully

It is only since 1933 when pneumonectomy became a feasible practice that surgical treatment has become possible Now the operation is standardised and the mortality has reached the relatively low figure of about 12 per cent The whole lung is usually sacrificed but lobectomy may sometimes be preferred if the tumour is placed peripherally and especially if there is no lymph gland involvement at the hilum The most favourable type of growth for long survival after surgery is that of squamous cell pattern. Most surgeons avoid surgery in young subjects who are victims of a rapidly growing tumour of undifferentiated oat-cell type

Pneumonectomy is carried out under cyclopropane anæsthesia the trachea is intubated in all instances The face-downward position on the table is an advantage A drip transfusion is in place from the outset The chest is opened widely after resection of the fifth or sixth rib or both, and a double rib spreader is inserted to maintain liberal access to all parts of the pleural cavity At the outset the hilum of the lung is inspected on all aspects to ascertain the degree of encroachment of the tumour and the extent of lymph gland involvement If pneumonectomy is decided on the pleura on all aspects of the hilum is divided freely (Fig 235) The order in which the individual structures are isolated may not matter greatly but it is a sound practice to clamp and divide the stem bronchus as a first step to protect the air passages from escape of infective material from a necrotic tumour Rough handling of the lung may dislodge malignant emboli and for that reason the superior and inferior pulmonary veins should be secured early Opening the pericardium facilitates this step especially when the disease encroaches on the hilum Isolation of the pulmonary artery is more difficult on the right side as the superior vena cava overlies its *proximal* part and is attached to it by an adventitial fold The vessel should be doubly ligatured and transfixed

The method of dealing with the bronchus is *important* It is essential to divide it as far from the tumour as possible and probably the risk of necrosis is diminished if it is divided almost flush with the trachea Closure of the bronchus is usually done with interrupted or mattress sutures of fine silk, though some prefer stainless steel wire The suture line is reinforced by a flap of pleura or even a strip of intercostal muscle Penicillin powder is dusted freely over the bronchial suture line A small drainage tube of water-seal type is placed in the lowest intercostal space It is kept for four or five days and eliminates the need for aspiration and should there be leakage of air from the

bronchus it overcomes the immediate embarrassing effects of tension pneumothorax

It is surprising how well such a seemingly drastic operation is tolerated even in advanced years One of the chief anxieties in the early stages of convalescence is the accumulation of mucoid secretion in the air passages and every effort by encouragement posture etc., should be made to check it Nowadays with the protection of penicillin leakage from the bronchus is uncommon It is unusual before the fifth day after operation the distress may be sudden and alarming and sometimes ends fatally more often it occurs insidiously

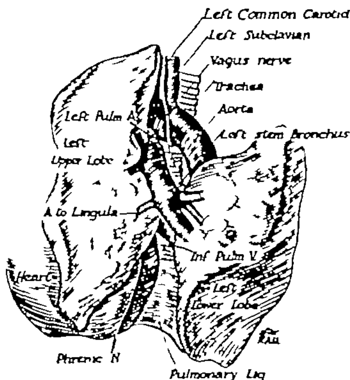


Fig 235

The distribution of blood vessels of the left lung as seen from behind. The superior pulmonary vein and the upper lobe bronchus come into view only after the lobar arteries have been divided.

and leads to infection of the pleura The accident though it delays convalescence need not be looked upon with gravity as following drainage healing ultimately occurs Long-delayed rupture of the bronchus (six months to a year after operation) is usually evidence of local recurrence of the tumour The large pleural space following pneumonectomy becomes obliterated by shrinkage of the chest wall deflection of the mediastinal structures and by large coagulum of organising fibrin exudate

The late results of pneumonectomy for bronchial carcinoma are not encouraging About half the surviving cases succumb to local recurrence or to metastases (especially in the brain and bones) within two years of operation

THE THYMUS GLAND

In selected cases of myasthenia gravis relief and sometimes cure may follow removal of the thymus gland The best results have usually been obtained in the few instances in which the thymus is the seat of an adenoma The operation is most likely to succeed in those cases in which the myasthenia is of recent onset and is of slow progression Immediately before operation an injection of 1 5 to 2 mg of prostigmine should be administered hypodermically The usual mode of approach to the thymus is by splitting the sternum longitudinally down to the fourth interspace The skin incision is T shaped the horizontal limb is placed immediately above the supra-sternal notch. The vertical limb is carried down to the periosteum of the sternum The infrahyoid muscles are separated in the middle line and the suprasternal ligament is divided. A finger is inserted behind the manubrium to create a space in the areolar tissues By means of a sternoclast the bone is divided in the middle line as far as the level of the fourth intercostal space At this level the sternum is divided laterally on each side Separation of the two segments of the sternum by a self retaining retractor affords excellent access with an ample view of the thymus pericardium and the aortic arch. Each lobe of the thymus is isolated from the pericardium and the areolar tissue of the mediastinum and the root of the neck. It can be enucleated intact with great ease In operating care should be taken to avoid opening the pleura

In the first few days after operation the myasthenic symptoms may be aggravated and larger and more frequent doses of prostigmine may be required for their control

Malignant tumours of the thymus (thymoma) are not amenable to surgical removal on account of their bulk and infiltrating character *They are usually of a reticulum cell or lymphosarcomatous character* The tumour is usually highly sensitive to irradiation It may disappear very rapidly during or after a course of treatment with very spectacular relief of pressure symptoms Local recurrence of the disease in the glands of the neck may occur it is sometimes delayed for several years the recurrences usually respond to a further course of treatment Spread of the disease to other parts of the body is unusual

B M D

REFERENCES

BARRETT N R. (1947). "Hæmothorax." *Lancet* 1, 103.
BROCK, R. C. (1946) "Anatomy of the Bronchial Tree. London: Oxford University Press.
JAMES, R. M. (1950) "Lobectomy and Pneumonectomy for Pulmonary Tuberculosis. *Edin. med. J.*, 57, 380
KEYNES, E. (1946). "The Surgery of the Thymus Gland. *Brit J Surg* 33, 201
SWEET R. H. (1950). "Lobectomy and Pneumonectomy in the Treatment of Pulmonary Tuberculosis." *J thorac Surg.*, 19, 298.
THOMAS, C. P., and CLELAND N P (1948). "Extrafascial Apicolysis with Thoracoplasty "Brompton Hospital Reports, 12, 23.

CHAPTER XXIX

SURGICAL THERAPY IN ARTERIAL HYPERTENSION

DEFINITION OF THE PROBLEM

IT is difficult briefly to define arterial hypertension for the arterial blood pressure is a constitutional attribute of the individual it *tends to increase with age and it is modified by many physiological* and environmental factors For convenience it may be stated that if brachial sphygmomanometric readings be taken with the patient *recumbent comfortable and at ease figures persistently in* excess of 150 mm Hg systolic and 100 mm Hg diastolic are pathological at any age

Hypertension occurs *clinically* as a feature of many syndromes *e g* in acute and chronic nephritis pyelonephritis congenital lesions such as renal hypoplasia and congenital cystic disease of the kidneys and occasionally following trauma to a kidney in cardiovascular lesions such as aortic incompetence arteriovenous fistula coarctation of the aorta and heart block in endocrine disturbances such as are produced by secreting tumours of the adrenal medulla or cortex or by basophil adenoma of the pituitary or as occur in thyrotoxicosis or at the menopause This list which is far from exhaustive illustrates what is termed secondary hypertension

Cases showing marked hypertension are however frequently encountered in whom methods of investigation presently available fail to disclose any pre-existing disease adequate to explain the elevated blood pressure This condition is termed essential hypertension A predisposition to essential hypertension appears to be genetically inherited If its victims escape intercurrent accident or disease the majority in the end will die of cardiac failure the remainder of cerebral vascular accident or renal failure It is important to note that in the course of their illness sufferers from essential hypertension show a slowly progressive decline of renal efficiency

It is customary to differentiate cases of benign and malignant hypertension The latter is characterised by progressive necrotising damage to the arterioles resulting *inter alia* in renal failure and azotæmia and in cerebral damage a clue to the nature of which is given by the visible changes in the *eye-grounds—œdema exudates and hæmorrhages* From the pathological point of view as Fishberg (1930) points out it is more useful and probably more exact to speak of the benign and the malignant *phase of hypertensive disease It is probable that* given time severe hypertension of any type will terminate with malig nant characteristics In the older age groups the disease tends to

march more slowly and commonly death from cardiac failure or cerebral vascular accident occurs before the malignant phase is reached Hence malignant hypertension will justifiably be regarded as typically a disease of the young

THE RATIONALE OF SURGICAL THERAPY IN HYPERTENSION

In secondary hypertension treatment may be directed towards the cause for example in certain of the cardiovascular and endocrine diseases mentioned above Unilateral disease of the kidney such as chronic pyelonephritis and renal hypoplasia falls into this category and on occasion nephrectomy will bring about a dramatic restoration to health but such cases are rare and the literature contains no more than fifty examples

In essential hypertension treatment is of necessity empirical since nothing is known with certainty regarding the etiology or pathogenesis of the unknown underlying disease process Were the hypertension known to be an isolated, bizarre and freakish departure from the physiological norm it would be justifiable to adopt any line of treatment to reduce it with a view to lessening the strain on the heart and vessels It is almost certain however that the hypertension is a reactive process Elevation of blood pressure occurs physiologically in work and combat on exposure to cold and on assumption of the erect posture In the majority of cases of secondary hypertension a reactive adaptation is equally clearly at work and reduction of the blood pressure without removal of the cause would be immediately harmful. The surgical methods presently used in the therapy of essential hypertension inflict just such a direct reduction of blood pressure and it is an inescapable conclusion that their effects will include a certain degree of damage to the organism Against this must be set the fact that severe hypertension will of itself lead in course of time to suffering disablement and death from the destructive effects of the constant overload on the heart smaller arteries and arterioles The striking of this balance demands much clinical and laboratory investigation and analysis of results in the light of a sound conception of the natural history of the disease As they occur in clinical practice only a small proportion of sufferers from essential hypertension are likely to benefit from surgery Fishberg (1948) assesses the figure at 4 per cent

SELECTION OF CASES OF HYPERTENSION FOR OPERATIVE TREATMENT

The objective of the surgeon is to lower the blood pressure sufficiently to relieve disabling symptoms and to diminish the load on the heart and strain on the arterioles and so delay the onset of cardiac failure and the renal and cerebral degeneration characteristic of the malignant phase At the best the end result must be a partially disabled patient For this reason prophylactic operation on a symptomless case is unwise Again where there is marked hardening of the arteries and arterioles a brutal reduction of blood pressure may readily result in

impairment of nutrition of myocardium and cerebrum and diminution of renal efficiency It is unjustifiable to incur an excessive risk in the treatment of a condition which may be rendered tolerable by rest and sedation One tries to select patients to whom one can give a reasonable promise of relief of symptoms increased expectation of life and reasonable post-operative efficiency—at the cost of a rather tedious surgical illness including two or more fairly painful major surgical operations

Age —preferably under forty rarely over fifty never over fifty five The older the patient the greater is the chance of organic deterioration being already present and furthermore the slower the natural march of the disease Pronounced arteriosclerosis at any age precludes surgery

Sex —On the whole women appear to do much better than men and especially so in the group in whom the first manifestations of hypertension were noted during pregnancy

Signs and Symptoms —To justify operation these must be severe Violent headache is the commonest indication It tends to be worse in the morning and to be centred in the occipital region Next in frequency is giddiness sometimes associated with nausea and vomiting Many patients suffer from precordial oppression and palpitation, from tinnitus and failure of vision A very characteristic complaint is of a feeling of overwhelming weariness which makes the contemplation of any exertion either physical or mental well nigh intolerable It is a common experience to have the patient beg for relief even though this entail considerable risk

Other cases are operated upon because of incipient cerebral damage as indicated by retinopathy or hypertensive encephalopathy In a third group operation is indicated because of evidence of strain upon the left ventricle without gross myocardial damage Left heart strain or congestive cardiac failure responding to rest are indications for operation Gross disorders of rhythm are absolute contraindications.

A single attack of focal cerebral damage may justify operation in an attempt to prevent recurrence Repeated attacks indicate widespread damage to the cerebral vessels complicated by thrombosis The resulting cerebral ischæmia is likely to be aggravated by any lowering of blood pressure and in such cases operation is contraindicated

As stated above it is rarely justifiable to operate on a symptomless patient on grounds of high blood pressure alone Occasionally however a young patient is encountered with a marked and rising hypertension which fails to respond to rest and medical measures In such a case with a diastolic pressure maintained at 130 mm Hg or more it is clear that grave complications must speedily develop and operation is therefore justified

Renal Function Tests —It is arguable that in a large proportion of cases hypertension even of so-called essential type is due to a renal lesion For surgical treatment to be successful however it is necessary that such a lesion be not materially greater than the physiological reserve of the kidneys These must demonstrate their capacity to excrete concentrated (S G 1020) and dilute (S G 1002) urine and to maintain the blood content of nitrogenous waste products at a satisfactory level (N P.N not over 40 mg per cent) by a satisfactory urea

clearance (not less than 40 per cent of normal) Easily demonstrable casts or albuminuria contraindicate operation Excretion urography is a useful complement to these tests and has the especial value that it will occasionally bring to light the rare case of unilateral renal disease causing hypertension curable by nephrectomy

Other Tests.—The clamant need is for a safe and simple test yielding objective and clearly expressible results which will enable the clinician to identify those few sufferers from hypertension who will be improved by operation Since however hypertension is a manifestation of a generalised and progressive disease and since the surgical procedures employed are extensive and destructive producing a profound physiological disturbance followed by a prolonged period of readjustment it

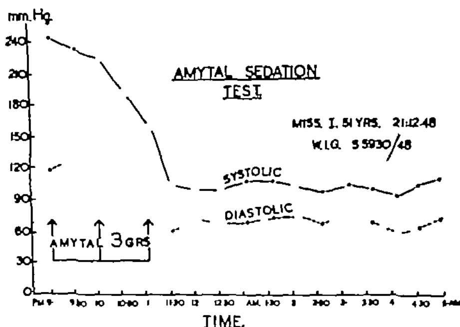


Fig 236

The Amytal sedation test. A "satisfactory" result. In deep sleep reduction in vasomotor tone has resulted in marked fall of blood pressure. The diastolic pressure has been reduced to values less than 100 mm. Hg

is clearly improbable that any test will ever be devised which will give a preview of the late operative results *Ad hoc* pre-operative tests must of necessity be empirical and their results helpful rather than decisively prophetic *Tests at present in favour are concerned with the* lability of the blood pressure During sleep the stream of impulses from the vasomotor centre subsides the output of adrenaline is curtailed cutaneous arterioles relax the heart beats less forcibly and the arterial blood pressure falls. If under such circumstances the fall from hyper tensive levels is striking the hypertension is said to be labile The convenience of the observer is served by ensuring deep sleep at a predicted time by the administration of sodium amytal

Sodium Amytal Test (Fig 236) —The test is carried out in the evening and early part of the night *Sodium amytal is administered in 3 doses* of 3 gr each (0 2 gm.) at hourly intervals Shortly thereafter the average subject will be in a profound sleep from which he can be roused with

difficulty Repeated blood pressure estimations are made and cl During the early hours of the test there is normally a rapid fall of s pressure and to a lesser extent of diastolic Thereafter there is rise towards former levels The result of the test is considered factory if the fall in blood pressure is considerable and if the di pressure falls below 100 mm Hg Too much significance ho cannot be attached to the result which narrowly interpreted registers the effect of near full vasodilatation in a given case of tension No post-operative state characterised by vasodilatation degree would be compatible wit form of active life In fact the ob of current surgery is much more li Finally it must be remarked that profound sleep following the admi tion of an adequate dose of amytal lowering of blood pressure is inev in all cases and an encouraging li may be demonstrated even in the l tension of chronic nephritis which suitable for surgical treatment

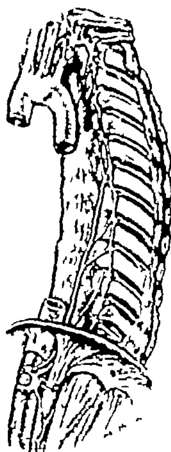


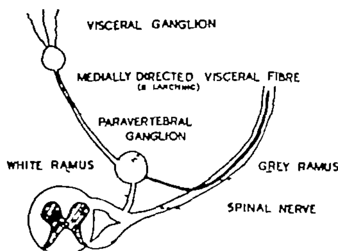
Fig 237
(*From Grimson*)
The thoraco-lumbar gangliocated trunks and the splanchnic nerves.

Tetra-ethyl Ammonium Compou Tetra-ethyl ammonium chloride an mide administered parenterally pro synaptic *blockade* of the sympa and parasympathetic systems Th is to a maximum of 0 gm intraven or 1 gm intramuscularly The effec widespread and complex and incl generalised diminution of vasomotor The blood pressure falls dramatica an extent depending principally o rate of administration but it is to secure systolic readings of 100 mm Hg The criticisms of amytal test apply with even greater to tests using these substances are so potent moreover that they useless in case-selection since ext lability can readily be demonst in every case It has been claimed in cases of hypertension due to tumour of the adrenal med administration of T E.A.B leads to a sharp rise of blood pre (LaDue Murison, and Pack 1948) If this prove constantly true test is of the utmost value in discovering occult cases of dangerous but curable type of secondary hypertension

Sympathectomies used in the Treatment of Hypertension (Figs 237 238) —Surgical attempts to modify essential hypertension have based on the removal of progressively greater amounts of the sympatl nervous system Peet (1935) carried out a supra-diaphragmatic sec of the splanchnic nerves and removed the adjacent thoracic sympatl

ganglia Adson (1936) removed the infra-diaphragmatic portion of the splanchnics and the adjacent lumbar ganglia Smithwick (1939) combined these techniques and his operation which is now generally regarded as the standard surgical procedure in this field consists in resection of the three splanchnic nerves on either side together with the paravertebral ganglia and connecting fibres from the eighth dorsal to the second or third lumbar ganglia In general the more extensive the operation the greater and more lasting is the fall of blood pressure achieved In some quarters therefore there has been a tendency to embark on ever more extensive sympathectomies including the upper

PLAN OF CONNECTIONS OF PARAVERTEBRAL CHAIN



ENERGISED BY THE WHITE RAMI THE CHAIN GIVES OFF
TWO SETS OF VASOMOTOR NERVES MEDIAL & LATERAL.

Fig 238

The peripheral (musculo-cutaneous) and the visceral (cardiac splanchnic, etc.) derivatives of the paravertebral system.

thoracic ganglia (Grimson 1941) and even to add intraspinal division of certain anterior (motor) nerve roots

Since the caudal limit of the sympathetic outflow is the first or second lumbar segment it is pointless to remove the paravertebral sympathetic below the second lumbar ganglion It is with greater difficulty however that the appropriate upper limit of the operation can be defined. In general the higher the operation is carried the greater and more permanent the depression of the blood pressure There is less chance of failing to interrupt certain filaments passing medially from the splanchnic system and descending on the aorta and oesophagus possibly capable of bridging in a progressive fashion the long post-operative gap in the paravertebral sympathetic If the extirpation be carried as high as the stellate ganglion the entire sympathetic outflow is interrupted and no centrally mediated increments of vasomotor tone are possible In addition the pathway is interrupted

of the cardio-accelerator reflex which exercises a material sustaining blood pressure

The rationale of these operations is in part factual and conjectural A sympathectomy will diminish vasomotor to area denervated and also prevent neurogenic increments of response to emotion work posture cold etc If the denerv be sufficiently large it will provide a wide sluice-gate in th arteriolar resistance against which the blood pressure is built so the latter will fail to reach the pre-operative level Again of the splanchnic nerves in addition to denervating the va of the greater part of the abdominal contents severs the connections of the adrenal medulla This is likely to dim secretion of adrenaline which normally acts synergistically sympathetic discharge It has been argued also that excisio twelfth dorsal and upper lumbar ganglia and their related ra

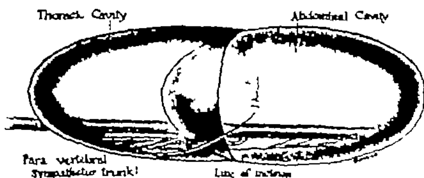


Fig 239

Schema indicating relation of peritoneal and pleural cavities and approach the lumbo-dorsal sympathetic

denervates the blood vessels of the kidney improves the renal tion and may diminish the production of renin It is regretta there is little support either clinical or experimental for th attractive concept

Technique of the Lumbo-Dorsal Sympathectomy for Hyperte The operation necessitates exposure of the paravertebral from the mid-dorsal to the mid lumbar regions In princ exposure is extra-serous *the pleural and peritoneal sacs bein* medially with their contents. On either side the peritoneal sa upwards into the thoracic cage (Fig 239) The anterior abdom is formed by a continuation of the *lower thoracic somites* a simple intersegmental incision in the lower thorax exposes conv both pleural and peritoneal sacs The operation is performed stages

At the first stage the patient is arranged lying on his (or h side (Fig 240) On occasion this posture causes a degree of embarrassment *and it is prudent to incur this during the first* The kidney bridge is raised A curved incision is made a littl *vertical than the line of the lower ribs running* up into the vertebral region at about D IX and terminating a few inches f

of the costal margin A lower rib is excised. If the twelfth rib be well developed then the eleventh is removed Where the twelfth is small it is better to remove the tenth The diaphragm is attached to the tips of the lower ribs and as the incision is deepened in the bed of the excised rib and carried forward through the three layers of the abdominal

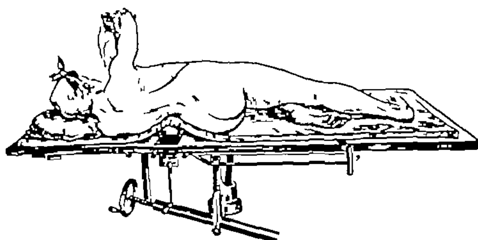


Fig 240
Position of patient on operating table and line of incision.

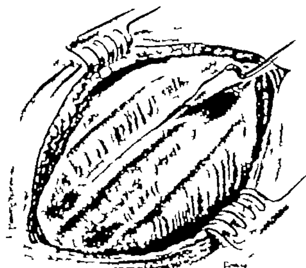


Fig 241
The superficial tissues having been separated, the tenth or eleventh rib is isolated subperiosteally

musculature the pleura and peritoneum are exposed (Fig 243) separated by the diaphragm which then or later is notched to a depth of about 1 in. A rapid infra-diaphragmatic exploration is made to verify the gross normality of the kidney and the absence of an adrenal tumour The pleural sac is now gently separated from the diaphragm and the inner aspect of the chest wall especially postero-laterally where separation is continued anteriorly to the vertebral bodies as high as D VI or D VII It is unusual to complete this stage with the pleura intact unless the pleural sac is obliterated by previous adhesions

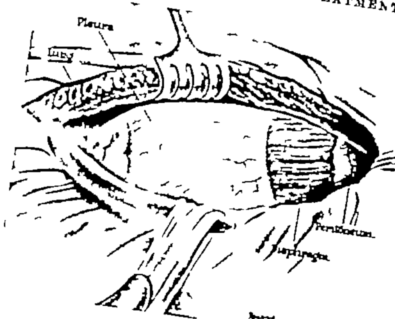


FIG 242

The rib has not yet been removed and at this stage is being used as a retractor. Pleura is widely exposed and the anterior portion of the incision exposes the edge of the diaphragm and below it, the peritoneum.

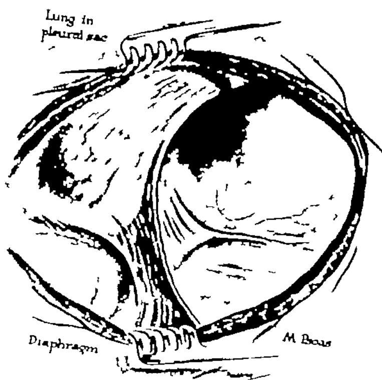


FIG 243

Pleura and peritoneum are separated postero-laterally and displaced anteriorly with their contents.

If a minute puncture is made it is best to enlarge it to a size materially greater than that of the glottis otherwise a tension pneumothorax will be produced The pleura having been stripped the elements of the sympathetic are partially concealed by the endothoracic fascia The most useful guide for their definition will be found in the long filaments running down and forward across the sides of the lower dorsal vertebræ from the ganglionated trunk to the splanchnics These are freed and traced forward to the splanchnics which lie in the posterior mediastinum directly in front of the vertebræ separated by less than 1 in from their fellows of the opposite side and back to the ganglionated

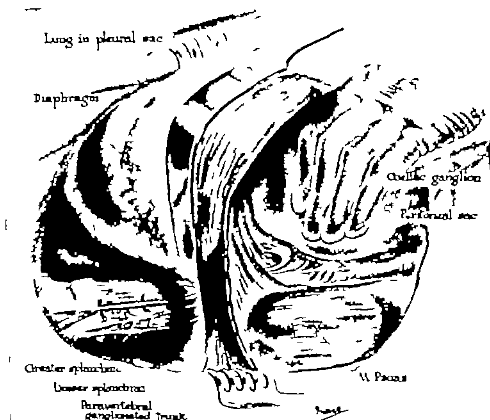


FIG 244
A little dissection exposes the paravertebral sympathetic system and its derivatives, lying external to the parietal fascial envelopes.

trunk which lies just in front of the heads of the ribs (Fig 244) In the lower thorax the trunk inclines rather sharply forward. The para vertebral trunk is divided above the eighth ganglion or higher and the great splanchnic nerve at the same or a higher level Both are turned down and freed progressively by division of the white and grey rami joining the ganglia to the intercostal nerves near their origins The intercostal arteries are at risk at this stage and the inadvertent division of an intercostal high in the chest can be a formidable complication Attention is now turned to the infra-diaphragmatic area With no difficulty the peritoneal and fascial sac is stripped forward and down exposing the inferior aspect of the crus of the diaphragm through which the splanchnic nerves are seen turning forward to enter the

Pain is usually troublesome in the post-operative period A useful addition to the normal armamentarium of analgesics is the intravenous procaine drip 1 pint of a solution of procaine hydrochloride 0 2 per cent in physiological saline administered slowly over a period of six hours

Post-operative Phenomena Gains and Losses—Death as a direct result of operative treatment should be extremely rare

The operation should result in a material reduction of blood pressure especially in the erect posture This effect is likely to be impermanent and the pressure tends to rise again in time to hyper tensive levels Nevertheless cases are on record in which relatively normal pressure has been maintained for ten years or more

The reduction of the blood pressure is generally accompanied by relief of such disabilities as headache giddiness and left-heart strain Objective evidence of this amelioration may be furnished by improvement of the electro-cardiogram and regression of retinopathy The latter appears to be due directly to lowering of the arterial pressure in the cranial circulation Œdema hæmorrhages and exudates commonly disappear but it is doubtful if there is any increase in calibre of the retinal arteries

The patient gains a sensation of well being to which he may for long have been a stranger He may feel that a great weight has been lifted from my brain Capacity for intellectual activity is often much enhanced Access of energy may tempt him to go beyond his physical powers for physical strength and stamina are not necessarily comparably increased. The more satisfactory results will be achieved in the case of the more intelligent patients engaged in sedentary or light occupations It is improbable that a labourer will ever return to his work The effect of operative treatment on expectation of life is difficult to assess though there is some evidence that the latter is increased.

Following operation however the hypertensive patient is not cured. He may be relieved of his more crippling complaints but in exchange he will have acquired certain new disabilities The most important of these are postural hypotension and disturbance of heat conservation In addition visceral sensation is greatly modified and the male patient will probably be sterile

In the intact subject assumption of the erect posture is accompanied by increased vasomotor tone generally and especially in the vessels both arteries and veins of the lower limbs The blood pressure is therefore higher standing than lying Following splanchnicectomy this adjustment does not occur but on the contrary blood tends to pool in the relaxed veins of the legs and abdomen and cardiac output falls owing to failure of venous return. In severe examples the blood pressure becomes unregistrable the pulse becomes increasingly more rapid and less easily palpable and the subject faints When the disability is of moderate degree this accident may be prevented by avoidance of standing still, since ambulation facilitates venous return The degree of postural hypotension and the resultant disability tend to become less with the passage of time In some cases the patient requires to wear for some months elastic stockings and corsets with

elastic abdominal pads The more extensive sympathectomies are followed by the most marked postural hypotension I feel that in such circumstances the disability outweighs the benefit of the operation but it may be that this radical re adjustment of hæmodynamics provides a margin of safety against recurrence of hypertension and tends toward a more prolonged alleviation

Following sympathectomy the feet are incapable of thermo-regulatory vasoconstriction and consequently whatever the environmental temperature they remain permanently warm (Fig 245) Unless

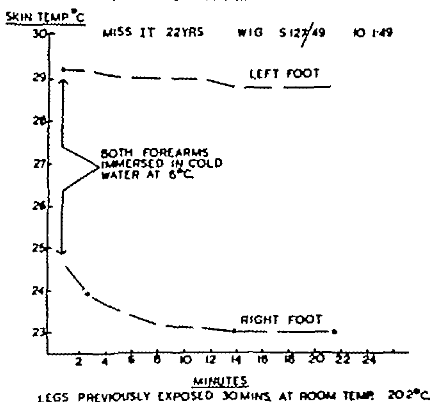


Fig 245

Failure of heat conservation following sympathectomy The sympathectomised limb remains hot despite heat loss which would normally demand thermo-regulatory vaso-constriction.

they be protected (and the patient will not unless specifically instructed, protect his constantly warm feet) considerable loss of body heat will occur As a result unless the environment be decidedly warm the hands will be in a state of thermo-regulatory vasoconstriction cold blue and damp This disturbance of vasomotor control may have more general results For example the patient may find himself much more susceptible to coryza and respiratory infections generally

Since the splanchnic nerves carry the sensory fibres for the abdominal viscera a radical operation of the type described abolishes visceral sensation virtually completely from the alimentary tract including the biliary tract and pancreas and the urinary tract It is probable

that post-operatively the patient will not be capable of appreciating biliary or renal colic and that even perforation may occur without previous pain (Ray and Neill 1947) Fortunately the sensitivity of the peritoneum remains unimpaired and the advent of complications dangerous to life will not escape unnoted.

In the male sterility is a common sequel of destruction of the upper lumbar sympathetic ganglia Erection and intromission are normal and orgasm occurs but there is no discharge of semen This disability is probably due to failure of the synergistic contraction of the internal vesical sphincter permitting reflux of the ejaculated semen into the bladder The nerve pathway appears to be the first lumbar splanchnic nerve descending through the presacral plexus to the hypogastric ganglion It is difficult to determine accurately the incidence of this complication or the degree of psychological disturbance which it occasions As it may not be an inevitable sequel it is probably unwise to adumbrate it in pre-operative discussion with the patient If it be complained of it is justifiable to make the encouraging prediction that it may not be permanent The recommendation has been made in some quarters that the upper lumbar ganglia be left intact on one side to prevent it

W A. M

REFERENCES

ADSON A. W CRAIG W McK., and BROWN G E. (1936) *Surg Gynec. Obstet.*, 62, 314
FISHBERG A. M. (1939). "Hypertension and Nephritis. Baillière, Tindall & Cox. 4th Ed.
—— (1948) *J Amer med. Ass.*, 137 670
GRIFFITHS, H. W C., and GILLIES, J (1948). *Anaesthesia* 3, 134
GRIMSON K. S. (1941). *Ann. Surg* 114, 753.
LA DUE, J S., MURISON P J., and PACK, G T (1948). *Ann. intern Med.*, 29, 914.
PEET, M. M. (1935). *Univ Hosp. Bull. Ann Arbor* 1, 17
RAY B S., and NEILL, C. L. (1947). *Ann. Surg.*, 126, 709
SMITHWICK, R. H. (1940). *Surgery* 7 1

CHAPTER XXX

CONGENITAL HEART DISEASE

Up till a few years ago the treatment of congenital disease of the heart and great vessels seemed an insoluble problem. The picture changed considerably however a few years ago when a surgical treatment for a patent ductus arteriosus was developed and the first operation performed successfully by Gross. Later Blalock and Taussig announced an operation for the relief of persons suffering from pulmonary stenosis and more recently Gross and Crafoord published reports of the successful surgical treatment of coarctation of the aorta. In a few years the three most common congenital abnormalities of the heart and great vessels have become amenable to surgical treatment. It is not improbable that with such remarkable progress it may be possible to attack surgically some of the other congenital intravascular lesions.

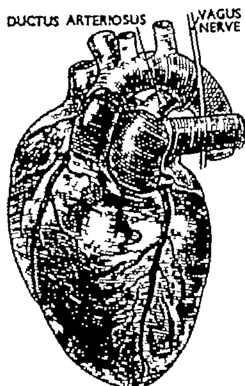


FIG 246

Line drawing of heart showing the ductus arteriosus—the natural pre-natal communication between the conus and the aorta.

Patent Ductus Arteriosus

The ductus arteriosus is a vessel which runs between the bifurcation of the pulmonary artery and the isthmus of the aorta. It is patent during intra-uterine life but normally closes after birth. It is of vital importance in foetal life since it enables the venous blood entering the heart from the superior vena cava to pass directly to the aorta and thence to the trunk, this route being necessary because of the atelectatic state of the lungs and the consequent small size of the pulmonary vascular bed. This short-circuiting action of the ductus arteriosus is no longer necessary after birth as the lungs expand and take up their permanent function of oxygenation of the blood and so the blood then takes its normal course through the expanded lungs.

Symptoms and Signs.—The patency of the ductus arteriosus is well tolerated in infancy and it is usually a surprise for the mother to be told that there is any abnormality in her child There is frequently, however limitation in the activity of the child He may be easily tired often breathless and often below weight, while the muscular development is usually below normal With growth these symptoms become more noticeable and a reasonably active life less possible

The characteristic diagnostic murmur of Gibson is systolo-diastolic in time and best heard in the second left interspace close to the sternum It has been likened to the sound in a machinery room or to peals of



FIG. 247
A radiogram from a typical case of a patent ductus arteriosus. It shows the dilatation of the pulmonary artery

thunder It is often inaudible in the early years of infancy but is usually heard about the age of five

An X ray shows enlargement of the pulmonary artery extending to the left as a semi-circular shadow lying between the aortic knuckle above and the ventricular mass below The heart is not usually enlarged

Blood pressure readings are of great diagnostic value There is a big fall in the diastolic level, with a consequent increase in the pulse pressure In the later age groups the systolic pressure increases but the diastolic remains fairly constant A normal child under ten might have a blood pressure of 98/68 and a pulse pressure of 30 while one with an open ductus would be 95/45 with a pulse pressure of 50 The larger the calibre of the ductus the lower will be the diastolic pressure

Even more important from the diagnostic point of view is the reading following on exercise. After a simple exercise test such as ten or twenty knee bends it will be found that although the systolic

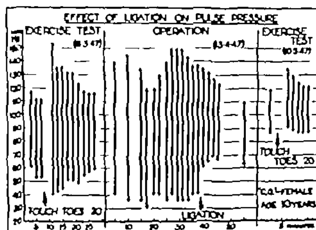


FIG 248

pressure and the pulse rate may rise the characteristic feature is a transient drop in the diastolic pressure often nearly to zero and its *prompt recovery after resting for a minute or two*

Complications.—The most serious complication of the condition is infection occurring as an endarteritis of the pulmonary artery and *spreading from there to the heart or along the ductus*. *The high* pressure jet of blood from the ductus damages the opposite intima and an atheromatous patch develops on which organisms are caught. Almost invariably the infecting *organism is the streptococcus viridans*. Although infection may occur in a younger patient the highest incidence is found in those of the third and fourth decades. The complaints are high fever *sweating loss of appetite and other symptoms of a general* septicæmia. Hæmoptysis and chest pain occur from infarcts into the lung. Blood cultures prove the presence of this complication and give some evidence *of its severity*. *An X ray shows a patchy con* solidation throughout the lung fields advancing and subsiding with the shedding and healing of the emboli

The heart suffers too from the strain put on it the strain being proportional to the volume of the leak.

Other complications such as aneurysmal dilatation of the ductus or *the pulmonary artery have been reported but are rare*

Pre-operative considerations—The mortality rate of operations in uncomplicated cases in children is less than 5 per cent and the risks so negligible that it is probably wise to advocate *operation during the* childhood period even though symptom free at the moment. The life expectancy is considerably less than normal possibly as low as 50 per cent *and of those who survive* most will suffer from impaired general efficiency cardiac embarrassment or serious fatigue. The operation becomes more serious in later life owing to the greater difficulty in *exposure, greater difficulty* in freeing the vessels from surrounding adhesions and the greater rigidity of the vessels. In the presence of an infected ductus surgery is the method of choice and should be

undertaken immediately after the institution of penicillin therapy Special indications according to Taussig, are stunting of growth, great cardiac enlargement low diastolic pressure threatened cardiac failure rheumatic heart disease superimposed upon a patent ductus and subacute bacterial endocarditis

Pre-operative Treatment.—The cardiac reserve should be improved with digitalis and the possibility of an active rheumatic infection should be excluded. The patient should be free from any infection—nasal dental or respiratory—and all of these should be most carefully looked for Penicillin is given for thirty-six hours beforehand. The blood is typed a supply procured and an infusion started before the operation in case of sudden hæmorrhage during the operation

The Operation.—The child lies on his right side with the right knee

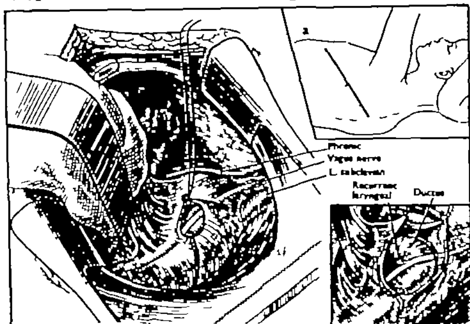


Fig. 249

The ligation of the patent ductus arteriosus. (a) shows the straight incision and thereafter the dissection and exposure of the ductus and the recurrent laryngeal branch of the vagus.

fully flexed and the left knee extended. A long strip of elastoplast is placed across his pelvis and over the sides of the table to ensure stability of the patient The left hand is fixed up to the top of the table to elevate the scapula out of the way

A long oblique incision is made from about the third spinous process in the mid line and going downwards laterally and forwards crossing the lower angle of the scapula to the anterior axillary fold. This incision goes through the skin and deep fascia and exposes the muscles Superficially the trapezius and latissimus dorsi and, at a deeper level the rhomboideus major and the serratus anticus are divided Bleeding points are sealed with diathermy The scapula is now mobilised, the hand inserted under it, the ribs counted accurately, and the fourth rib localised. This rib is now resected subperiosteally from its vertebral attachment to the anterior axillary line The removal is subperiosteal so that reformation may take place and prevent any scoliosis later

The chest is now opened and the lung allowed to collapse A self retaining retractor is inserted and opened and a good wide exposure is thus ensured The lateral aspect of the mediastinum is now open to view and the phrenic nerve and the aortic arch can be seen Behind the former and below the latter a finger palpates the region of the ductus and the vessel is easily and accurately located by the characteristic thrill which can be abolished by finger pressure With this point as its centre a vertical incision of 5 to 6 cm is made behind and parallel to the phrenic nerve The dissection of the ductus is now commenced and the anterior part of it is cleared by a pledget of wool Care is taken to see that there is no aneurysmal dilatation of the pulmonary artery overlapping the ductus. If this is present it is carefully dissected

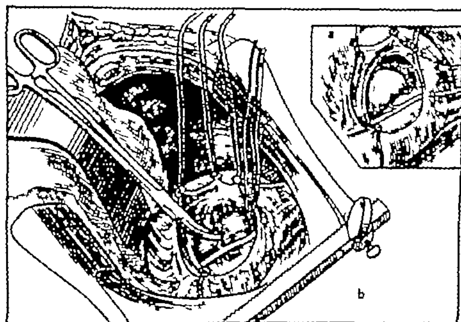


Fig 230

This shows the encirclement of the ductus by special dissecting curved forceps and the passage of the three ligatures.

and swabbed down to ensure a good exposure By clearing the posterior flap of pleura the vagus nerve is made visible and its recurrent branch traced downwards It will be seen to wind round the ductus so determining exactly where the ductal dissection will start

A special type of cystic duct forceps is used with a blunt nose and no teeth on the end A series of these with different curves is used The long handles give good access and good control They are used to insinuate and burrow round the ductus starting in the angle between the ductus and the aorta below but avoiding the recurrent branch of the vagus nerve By alternate insertion and opening of the forceps a way is gradually made farther and farther round When the route has been made as far as conveniently possible behind, then a start is made from the proximal angle of the aorta and the ductus The posterior junction of the two channels is the most difficult part as often there is a pretty firm attachment of the ductus to the bronchus and often the two dissections seem to be in different lines of cleavage

In the infected cases it is particularly necessary at this stage to go slowly for the adhesions here are more firm and impenetrable and the ductus itself more friable This procedure demands patience and perseverance Once the fully curved forceps are round and the blunt nose visible at the other side of the ductus, the channel behind the ductus may be enlarged by opening the forceps

In the early cases done it was found that there was a great tendency for a recanalisation of the ductus to take place after it had been ligated To prevent such a happening Gross suggested a division of the ductus The simplest method is to obliterate the ductus over a reasonable length close to its aortic end with fairly strong silk. No 5 Chinese Twist Silk is used and three ligatures are applied. These are first passed round the ductus and then tied as tightly and as near the aorta as possible carefully avoiding the recurrent laryngeal nerve A surgical knot is used and the ends left rather long In this way a fair length of the ductus is completely obliterated and liability to recanalisation unlikely

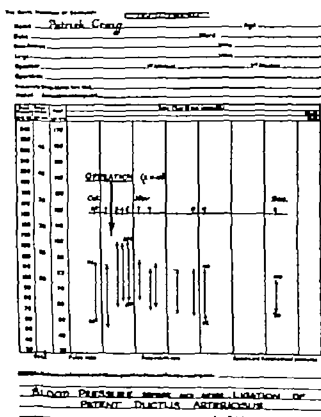


Fig 251

Penicillin is applied to the area but the mediastinal pleura is left open The chest is now closed in layers using silk stitches A catheter is left in the chest at the posterior end of the wound till the last moment before closing to allow the anæsthetist to inflate the lung No drainage is used.

After operation the child is put in an oxygen tent and remains in it for about two days The blood drip is removed the same day and luminal and heroin used to keep the child comfortable and well sedated. A radiogram is taken the following morning and when necessary the chest is aspirated, but this is usually unnecessary

Results of Operation.—Following surgical closure there is no important change in the systolic pressure but the diastolic shows an immediate rise This is evident on the operating table as soon as the ductus is tied A stethoscope is used at the operation and it is interesting to observe the complete disappearance of the Gibson murmur

The activity of the heart is lessened as shown by the diminution of the forcefulness of the apex beat

The cases with a retarded physical development show a rapid gain in weight As an example of this a boy of 13 a debilitated child

with a fairly big heart gained 43 lb in weight and 8 in in height in the two years following operation

The Effects of Operation on the Infected Case—Within a few minutes of ligation of the ductus in an infected case the blood stream becomes sterile A typical example was a case which showed eighteen

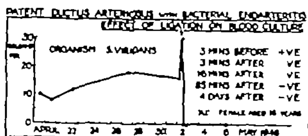


Fig. 232

to twenty colonies of streptococcus viridans before operation while sixteen minutes afterwards culture was negative and remained so

Complications of the Operation—Hæmorrhage is always a possibility especially in the infected cases where the walls are friable and very adherent Sepsis and pneumonia are prevented by penicillin and combated by it when they occur Injury to the recurrent laryngeal nerve should be avoidable if the dissection is carried out with care

Results of Operation—The mortality rate for uncomplicated cases is under 4 per cent while in infected cases it is higher but should be under 15 per cent Recanalisation will occur in a certain number of cases approximately 5 per cent unless division of the ductus has been the operative method of closure

Division of the ductus is a much more dangerous procedure except when done in selected cases by a surgeon experienced in this method.

Coarctation of the Aorta

Coarctation is the name given to a narrowing or complete obstruction of the aorta, occurring at or shortly after birth It is believed to occur as a result of an extension into the adjacent portion of the aorta of the fibrotic process which is concerned in the closure of the ductus arteriosus As the ductus arteriosus becomes obliterated the tissue which lies in the wall of the aorta also contracts, and thereby causes the stenosis.

There are two distinct types of coarctation (1) The infantile one in which a long segment of the aorta is narrowed, the segment extending from the left subclavian artery to the point of entrance of the ductus arteriosus The ductus is usually patent in such a case but should it close as normally it would after birth it is improbable that the child will live (2) In the adult type the stenosis is more localised and occurs at an earlier stage so that there is time for the development of a collateral circulation and even if the ductus arteriosus does undergo normal closure the blood from the ascending aorta reaches the descending aorta by the devious pathways of the collateral circulation

This circulation develops principally in three anastomotic channels

the first round the apex of the thoracic cage by the superior intercostals and the inferior thyroid the second in the shoulder girdle area—the transverse cervical transverse scapular and subscapular being the arteries involved the third way is by the internal mammary artery of which the superior epigastric branch anastomoses with the deep epigastric

Clinical Findings —The condition is more common in boys who are usually well developed and have an early onset of puberty Usually coarctation produces few symptoms in childhood. The outstanding feature is the difference in the strength of the pulse in the upper and lower extremities the arm pulse being strong and powerful while the leg pulse is weak or absent Hypertension in the upper extremities is common. The systolic pressure may be above 200 mm. of mercury and the diastolic more than 100 It is obviously of the greatest importance in cases of high blood pressure taken in the arm to examine also the femoral pulse

The symptoms are usually minimal and are related to the con striction of the aorta falling into two groups—one due to the hyper tension in the upper extremities and the second due to the sluggish circulation in the lower limbs Headaches and throbbing in the head are troublesome Numbness and coldness of the lower extremities are not uncommon some complaining of weakness in the legs An important diagnostic sign is the difficulty in the healing of wounds in the lower extremities presumably from the poor circulation

On examination there is usually visible pulsation in the episternal notch There is good clinical evidence of the collateral circulation producing pulsation in unusual places as in the supra-clavicular fossa and in the inter-scapular region along the margins of the scapula Murmurs are heard over any of the vessels of the collateral circulation and not infrequently it is the occurrence of a murmur in the inter scapular region which suggests the possibility of a coarctation of the aorta

On X ray examination the ascending aorta may be dilated and visible to the right of the sternum. Notching of the ribs is seen in the X rays as the most characteristic single feature It is due to the erosion of the under margins of the ribs by the marked dilatation and pulsation of the intercostal arteries

Complications.—The most serious complications are those directly referable to the high blood pressure in the head and upper extremities Cerebral accidents are common. Rupture of the aorta has been noted while aneurysmal dilatation of the descending aorta is sometimes seen. Seventy five per cent of the patients die of cardiac failure before the age of 40 although certain of the remaining cases live a long and active life The vascular abnormality may be the seat of a superimposed infection especially with the organism streptococcus viridans

Following on valuable experimental studies on dogs Crafoord carried out successfully an excision of the stenosed area of the aorta in suitable cases

Indications for Operation.—The indications for surgical treatment depend to some extent on the symptoms but it is quite certain that it

should be done before the age of 14 as at an early age the vessel is too narrow for satisfactory suture and later there is more likely to be some arteriosclerotic degeneration of the vessel wall making the outlook rather more precarious In cases of extreme hypertension the operation is certainly justified and it is probably justified if the patient has an intractable sub acute bacterial endocarditis

The Operative Treatment—The patient is given penicillin before the operation and a blood drip is set up The exposure is a postero lateral one very similar to the one used in patent ductus arteriosus but rather more extensive while the fifth rib is removed rather than the fourth. Short segments are also taken if necessary from the angle of the fourth sixth and seventh ribs There is usually a very troublesome ooze from all the intercostal muscles and other structures indicating the vascularity of the chest wall and the very prolific collateral circulation

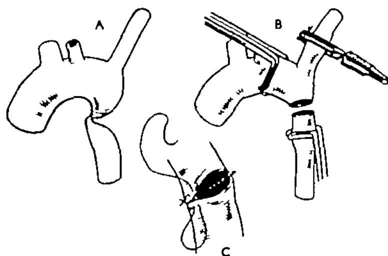


FIG. 233

The method of operation in coarctation of the aorta. A The stenosis after dissection B, after resection of the stenosis and with clamps in position C the suture line in progress.

It is notable when the chest is opened that a great number of anastomotic vessels can be seen all over the pleural cavity The intercostals are large and perhaps the largest is the internal mammary which reaches the calibre of a normal subclavian artery The desired portion of the aorta is brought into view by incising the mediastinal pleura over the arch and between the phrenic and vagus nerves In a very localised stenosis it is sometimes not possible to see it at this stage as it is obscured by areolar tissue but it can be palpated as a stenosis of the aorta just distal to the subclavian artery It is only after the areolar tissue has been dissected free that it can also be made visible Many vessels have to be ligated in dividing the pleura The intercostal arteries are extremely large and may be as much as 7 mm in diameter They are usually tortuous and apt to be thin walled and friable and great care has to be taken in putting ligatures round them especially close to the aorta

When the aorta is exposed the situation is reviewed and the type of stenosis identified If it is a short stenosis in length it is probably

a suitable case for operation The aorta is exposed then and freed and elevated and the intercostal vessels divided between ligatures so freeing a large segment of the arch of the vessel The left subclavian is then freed from its surrounding tissue and a tape is put round it to allow a better degree of dissection behind it and on its medial aspect Similarly a tape is put round the aorta At the lower part of the arch of the aorta there is a good deal of fibrosis making it much more fixed This would appear to be where the obliterated ductus arteriosus enters the aorta Ligatures are placed round the ductus after it is dissected free—quite a difficult matter because there is considerable surrounding fibrosis Division of the ductus is required for complete mobilisation of the aorta and although it is presumably obliterated it must be ligated before division This dissection must be carried out extremely slowly and carefully in order to avoid injuring any of the vessels and setting up uncontrollable bleeding

Clamps are now applied proximally and distally Blalock s clamp may be used on the aorta on either side of the coarctation and a small bull-dog clamp on the subclavian An alternative is to use a Potts clamp proximally and a Blalock distally Note is now taken whether it is likely to be possible to get the ends together after excision of the obstruction Should this be so the stenosis is resected with a sharp knife until the ends appear to be reasonably equal in calibre and of good size The exsected stenosis has often an opening little more than 1 or 2 mm in calibre Anastomosis is carried out with an arterial suture of 3/0 silk (Deknatel) starting at the medial aspect of the aorta with the knot on the outside Thereafter a running suture is put along the posterior aspect in much the same way as Potts does his operation for a pulmonic stenosis—an easier method than the usual type of Carell invaginating suture that is used by Gross When the posterior line of sutures is completed it is anchored by tying it to another suture which is then continued round the anterior aspect and is tied to the long end of the original knot Before the clamps are removed half a pint of blood is run in rapidly intravenously and the head end of the table lowered The distal clamp is then removed very slowly followed by the others also slowly A swab is held against the suture line for about a minute before finally freeing it

The post-operative treatment is much on the lines of that after operations for pulmonic stenosis with one notable exception. There is a great danger in aspirating the chest afterwards of damaging a large intercostal vessel and causing serious or even uncontrollable hæmorrhage It is probably wise to leave in a very small catheter in the chest and clip it opening it up and aspirating through it if necessary It may be removed in forty-eight hours

Probably slightly over 10 per cent of cases operated on are found to be inoperable The operative mortality is difficult to state but in the hands of an expert like Crafoord it is probably reasonably small making the operative interference justifiable The figure will depend to a great extent on the age of the patient—being reasonable in the early years of the second decade—on the local conditions found, and on the experience of the operator

TETRALOGY OF FALLOT

The commonest cause of cyanosis in congenital heart anomalies is the tetrad or *tetralogy of Fallot* the four main features being stenosis of the pulmonary artery dextra position of the aorta so that it overrides the septum a high interventricular septal defect and right ventricular hypertrophy If a child with this condition survives it is a blue baby cyanotic with little or no exercise tolerance with clubbed fingers or toes and with typically a preference for the squatting position

The pulmonary stenosis usually involves both the pulmonary artery and the pulmonary conus of the right ventricle Dextra position *of the aorta means that the aorta although it rises from the left* ventricle overrides the ventricular septum and receives some blood directly from the right ventricle A high interventricular septal defect is the inevitable result of the overriding of the aorta The direct consequence of the dextra position of the aorta is a persistent venous-arterial shunt Right ventricular hypertrophy results from the increased work demanded from the right side of the heart since owing to the pulmonary stenosis there is difficulty in the expulsion of blood from the right ventricle

Clinical Picture —A typical case of tetralogy is a child of five to ten who is cyanotic and displays the secondary manifestations of cyanosis —that is clubbing and polycythæmia—who experiences dyspnœa on exertion in whom a systolic murmur can be heard who has a boot shaped heart in the X ray and in whom an electro-cardiogram shows marked right axis deviation The outstanding features are intense cyanosis and the clubbing of the extremities combined with a heart *of normal size* So *long as the ductus arteriosus remains open* as it may do for some time after birth the syndrome may not be distinctive and, indeed during the first few weeks of life there may be no visible cyanosis The intensity of the cyanosis when it does arise varies with the hæmoglobin reading and the percentage of reduced hæmoglobin in the blood this depending upon the degree of stenosis If extreme there is barely enough oxygen to meet the requirements of the body and even slight exertion causes dyspnœa Clubbing of the extremities develops as a result of the persistently poor oxygen saturation of the arterial blood and the compensatory polycythæmia which varies with the intensity *of the cyanosis and the percentage of the available* hæmoglobin The red cell count may be between six and nine million and may even reach more than that Oxygen saturation of the arterial blood is low If the child can walk only a few feet it is usually down to about 30 per cent and when it drops to 20 or 25 the child is seldom able to walk His exercise tolerance is therefore limited and dyspnœa on exertion is common and is accompanied by an abrupt fall in both the oxygen content and the oxygen saturation of the arterial blood Squatting is a common habit among cyanotic children who suffer from inadequate circulation to the lung They appear to be able to breath more easily *in this position Some even sleep with their knees* bent up on their abdomen There is commonly stunting of growth and the

children are thin, have difficulty with their digestion and put on weight slowly Puberty is often delayed

Although the heart is strikingly small the right ventricular wall is hypertrophied Usually there is a thrill over the base of the heart A murmur occurs even more constantly than does a thrill This is systolic in time and is heard best along the left border of the sternum but is not transmitted to the vessels of the neck

The X ray picture shows a heart that is characteristically boot shaped the upper margin of the cardiac silhouette to the left of the

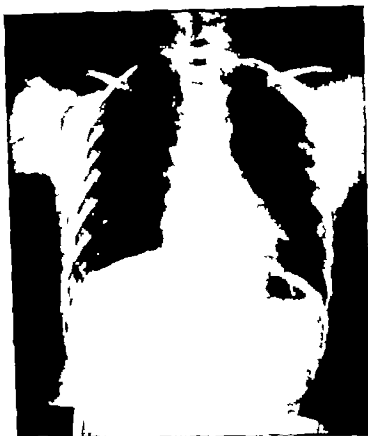


Fig 254

A radiogram showing the diminished pulmonary bulge producing a typical boot-shaped heart.

sternum being concave in contrast to the normal convexity A right aortic arch is relatively common occurring in about 25 per cent of all cases of tetralogy

The chief complications of the condition are thrombosis and sub acute bacterial endocarditis The former is due to polycythæmia and cerebral thrombosis is a serious and not infrequent complication during or immediately after operation

The operation which has been designed for the tetralogy of Fallot increases the circulation to the lungs The object is to increase the pulmonary blood flow and remove the stimulus for the development of polycythæmia and to permit the patient maximum activity without placing undue strain upon the heart Experience has shown that this

is obtained when there is an oxygen saturation of the arterial blood of approximately 80 per cent The essence of the operation is the creation of an artificial ductus arteriosus by the anastomosis of an arterial vessel into the pulmonary artery The systemic vessel must have a higher blood pressure than the pulmonary artery so that the blood will flow into the pulmonary artery

Indications for Operation.—The operation is indicated in all those who are severely handicapped and those who have little to lose and in whom the outlook is poor and who are likely to die should something not be done The mortality rate in infants and adults is higher than in children It is usually wise not to operate until the child is over two but it should be done before he reaches adult life Five to twelve would appear to be the most suitable age group though it is hardly justifiable to let a baby die of anoxæmia while waiting for him to reach the more favourable age Practically every blue baby should have its chance as in all probability a successful operation will ensure a reasonably normal life whereas without operation the child is unlikely to live for more than a few years

The commonly used operations in such cases are three —

1 A systemic vessel to the pulmonary artery
2 The aorta to the pulmonary artery—a side-to-side anastomosis (Potts operation) or
3 An operation on the stenosis itself after the nature of a valvotomy

It is necessary in the first place to know whether it is a right or left-sided aorta If this is not obvious by an ordinary X ray and clinical examination then a barium swallow is given and this shows it up with a fair degree of certainty If the aorta is on the right side the anastomosis may be carried out on the left side and the subclavian branch of the innominate used to carry out the anastomosis Owing to the lower position of the pulmonary artery on the right side a Potts operation is very difficult even if possible If it is a left sided arch the normal the main choice lies between a right sided subclavian branch of the innominate into the pulmonary artery or a left-sided aortic pulmonary artery anastomosis after the manner of Potts It is probable that the Potts operation would be the one advisable in younger children where the subclavian artery is very small since it allows a greater increase of blood circulation to the lungs in that the anastomotic opening may be made to any extent that one desires though actually there is a maximum since if it is made too big cardiac failure may result when the anastomosis is opened up

Anomalous Anatomy—Various disturbing anomalies may be found at this operation It may be that there is only one pulmonary artery the second lung being fed only by the bronchial vessels The pulmonary artery may occasionally be very small and lying posteriorly and inferior to the vein while not infrequently the division of the pulmonary artery into its branches occurs early so that it is not possible to do the anastomosis

The origins of the great vessels from the aortic arch are also subject

to great variation Occasionally a left superior vena cava is recorded in anatomical literature

Preparation for Operation.—Where necessary it is a good practice to give digitalis for some time before Fluids should be administered liberally since the child should not be dehydrated *Systemic penicillin* therapy is begun before the operation

The Operation (Blalock)—Cyclopropane is used as an anaesthetic and controlled respiration *is considered to be most important as it is* so much less tiring for the patient

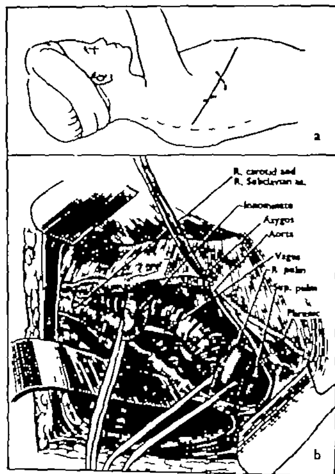


Fig 255

The operation for pulmonary stenosis. (*a*) The incision on the right side. (*b*) The direction of the pulmonary artery and the innominate artery and its branches.

The patient is placed on one side with his other arm pulled up towards the head so tilting the scapula The incision is made from the second spinous process downwards and forwards across the lower angle of the scapula to the edge of the sternum. The chest is entered after subperiosteal resection of the fourth rib and the *lateral* mediastinal wall seen. The azygos vein is divided between ligatures allowing a better *exposure of the* pulmonary artery This artery is now dissected out until it is pretty freely mobilised up to the pericardium while its branches are also freely mobilised giving as long a free length as possible The artery is *temporarily* occluded and the effect on the

patient is observed in case there is no *similar vessel* on the opposite side Dissection is now carried beneath the superior vena cava and the aortic arch and the innominate branch of the latter identified This vessel is followed distally to its branches a dissection

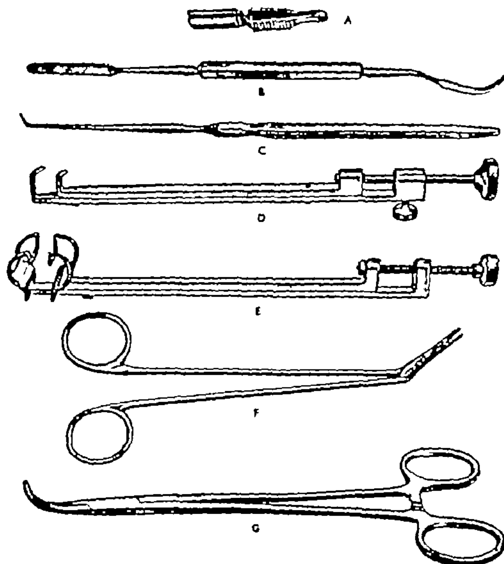


FIG 250

The instruments in use in operation on congenital abnormalities of the great vessels. A, *Small bulldog clamps.* B, Director to separate walls after incision into great vessels for side-to-side anastomosis C, Angled probe used for a similar purpose. D Blalock clamp for occlusion of great vessels and used in different sizes. E, Modification of Potts clamp used to occlude but only partially the aorta. F Small angled scissors to enlarge incisions in the great vessels. G *Dissecting forceps for encircling great vessels.*

that is facilitated by encircling it with a piece of tape The subclavian is located by the vagus and the recurrent branch in its vicinity on the right side and after these structures are identified it is possible to dissect the mediastinal tissue with greater freedom

The subclavian carotid, and innominate arteries are mobilised as

far as possible to allow good co-aptation for the anastomosis A Blalock clamp is now applied to the subclavian artery at its proximal end A ligature is then placed just distal to where a large branch is given off and the branch itself ligated The subclavian is divided just proximal to the ligature and across the exit of its branch so giving a larger calibre of vessel for anastomosis The end of the subclavian is freed from adventitia to avoid it being caught in the suture and causing constriction of the anastomosis

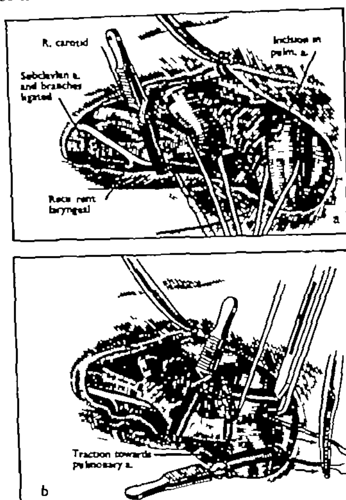


FIG. 237

Operation for pulmonary stenosis: (a) Subclavian ligated and about to be divided after proximal occlusion with a bulldog clamp; (b) bringing down the subclavian for anastomosis to the right pulmonary artery

The pulmonary artery is now examined and when fully mobilised, it is occluded proximally with a Blalock clamp and at the distal end a silk ligature is placed twice round it for traction and occlusion. More length may be got if the branches are encircled rather than the main vessel Some degree of co-aptation may be secured by pulling the silk ligatures around the pulmonary artery up towards the subclavian A transverse opening is now made in the superior surface of the pulmonary artery a trifle larger than the end of the subclavian This is made towards the proximal part of the freed

artery but not too proximally lest this prevent its ligation in case of trouble

The anastomosis is now performed between the end of the subclavian and the side of the pulmonary artery using 5/0 silk on an atraumatic curved needle The suture is a continuous everting stitch approximating the two vessels together It is a series of mattress stitches The posterior row is placed along its whole length but left loose until this row is completed and only then pulled taut This allows better access for putting in the stitches Stay sutures are then placed at either end to anchor the continuous suture and prevent any degree of purse-string effect, which might of course produce some constriction The anterior row is now sutured with the long end of one of the stay sutures using a similar type of stitch although a simple continuous over and over stitch is quite as good This row is completed by knotting the suture to the retained end of the other stay suture

The distal pulmonary occlusive silk ligature is removed first then the proximal clamp and during all this time a wet swab is kept on the suture line until the pulmonary artery has completely opened up and for some time afterwards This allows any slack in the suture line to be taken up by the expanding vessel The swab is then momentarily removed and if there is no more than slight oozing it is reapplied When this is satisfactory the subclavian clamp is very slowly loosened and the effect watched Any slight ooze usually stops with sponge pressure but if it is considerable it may require an additional suture Fibrin foam is useful if the leak is persistent The mediastinal pleura is left open penicillin placed in the wound and the chest stitched up in the usual manner care being taken to see that the lung is fully expanded before the final stitches are put in After the chest is closed air is aspirated with an artificial pneumothorax apparatus and this helps lung expansion

The Operation of Aortic-pulmonary Anastomosis (Potts)—This operation is carried out on the side of the aortic arch In the normal left-sided arch the author uses a postero lateral approach The child lies on its opposite side and the chest is entered by removing the fourth rib from near its vertebral end to the anterior axillary line Should more room be required it is easy to divide the rib above and below to obtain a wider exposure The pulmonary artery is dissected and as long a segment as possible is mobilised—probably a little longer than is necessary in the ordinary Blalock type of operation It is then occluded for a few minutes to determine the patency or otherwise of the opposite artery One and a half inches of the distal part of the arch of the aorta is completely mobilised after ligation and division of all its bronchial and intercostal branches Silk ligatures are passed round the distal and proximal extremities of the mobilised segment of the pulmonary artery Each ligature is placed round twice but not tied A Potts type of clamp is applied to the mobilised portion of the aorta and approximation of the two vessels is obtained and maintained by tying each silk ligature to the corresponding end of the aortic clamp after having pulled them tight enough to occlude the artery By means of a long handled small bladed scalpel a longitudinal incision is made

in each vessel These incisions are parallel to each other and about $\frac{1}{4}$ in in length but may of course, be a little longer in an older child 5/0 silk stitches are used in a curved atraumatic needle and a simple continuous suture is used for the posterior layer not the usual everting stitch as used by Blalock The first suture is anchored at its commencement by a knot and fixed at the other end of the posterior row by



Fig 258

Potts method of direct anastomosis of the aorta to the left pulmonary arotry (*a*) Incision (*b*) dissection and freeing and encirclement of the left pulmonary artery; (c) clamp applied and incisions made. The incisional lines are kept apart for suturing by director or probe (*d*) the posterior layer

tying it to one end of a fixed stay suture The other end of this stay suture is used for the anterior layer of the anastomosis This again is a simple continuous suture and it is tied at the finish to an end which has been retained at the knot at the commencement of the posterior layer

The anastomosis is supported by firm pressure with a wet swab while the occluding devices are gradually removed from the vessel Slight oozing may be stopped by swab pressure and fibrin foam is

used in some cases if necessary The chest is closed in the usual manner without drainage

Post-operative Treatment.—The patient is placed in an oxygen tent on his return to the ward and kept in it for two to three days and then by degrees the oxygen tent is discarded Great attention is paid to the coughing up of sputum as its retention is so apt to produce pulmonary collapse Coughing is encouraged and if there is any collapse or suggestion of it there should be no hesitation in performing bronchoscopy The patient is allowed up at the end of a week. Heparin is not used as a routine but if there is evidence of cerebral thrombosis or thrombosis at the anastomotic line its immediate use is justified. The patient is kept very quiet and is sedated with heroin as rest is most important at this period

***Results.**—The mortality rate varies according to the choice of cases* as in all surgical procedures as well as with the experience of the surgeon Blalock s overall mortality rate in over 600 cases is well under 20 per cent The most common cause of death is cerebral thrombosis though cases are reported of hæmorrhage at and after the operation

The result of a successful operation is quite wonderful The blueness is replaced by a normal pink complexion and activity is no longer limited Most of the patients show an improvement in the colour of the mucous membrane as soon as the anastomosis is com pleted. A typical ductus murmur can then be heard and the pulse pressure rises The clubbing of the fingers and toes gradually becomes less apparent Activity becomes a pleasure to the patient who could previously manage only a few yards and can now do several miles

VALVULOTOMY

In recent years attempts have been made to cure valvular stenosis by more direct methods Twenty five years ago Cutler and his associates made such attempts without success but with such great advances in surgery and anæsthesia as have occurred in the intervening years Brock has had some gratifying results recently in pulmonary stenosis while Harken and Bailey have shown the possibility of success in treating mitral stenosis

Valvulotomy for Pulmonary Stenosis.—The left pleural cavity is opened through the second interspace The pulmonary artery area is palpated and a thrill of fine high pitched frequency is felt suggestive of the valvular stenosis The pericardium is opened and the pulmonary artery is found to be dilated like an aneurysm a condition due to the thin but powerful jet of blood being forced through the tiny hole of the stenosis In some cases Brock suggests the use of a cardioscope to verify the diagnosis of stenosis When valvulotomy is decided on two rows of three interlocking mattress sutures of linen thread are inserted in the wall of the right ventricle which is incised between them The mattress sutures are crossed and held by an assistant to control hæmorrhage from the incision The valvulotome has a gently curved shaft ending in a blade shaped like a spearhead and carrying a short probe-end , *the two edges proximal to the probe-end are cutting* the

shoulders and the retreating edges are blunt The valvulotome is inserted and passed into the pulmonary artery A curved dilating forceps is then passed and opened fully The heart wound is closed by two linen thread mattress sutures and the pericardium sutured to it A 1 per cent procaine solution is used on swabs or by injection into the pericardium throughout the operation The first three cases operated on by Brock survived and were greatly improved

Operations for Mitral Stenosis.—Attempts to cure this condition have been made by various surgeons Harken has attempted to mobilise the rigid cusps by dividing the commissures (valvuloplasty) and he has also removed a segment of the posterior leaflet Bailey on the other hand has confined himself to commissurotomy in which he extends the cut into the normal tissue surrounding the fibrotic area of the valve believing that the raised auricular pressure will keep the artificial opening patent The latest development is that of Gordon Murray of Toronto who has succeeded in animal experiments and in two patients with mitral stenosis in removing one mitral leaflet and replacing it by an artificial leaflet consisting of a section of cephalic vein turned inside out and strengthened by palmaris longus tendon Bland and Sweet have used a less hazardous method by creating an extra-cardiac venous shunt between the right dorsal segmental inferior pulmonary vein and the nearby azygos vein by non-suture anastomosis with a Blakemore s vitallium tube

Mitral valve surgery is still a hazardous undertaking fraught with great technical difficulties and dangers Bailey indeed, lost seven of the ten patients operated on him by the method outlined above

W M.

CHAPTER XXXI

HERNIA

"It will appear excess of daring to write at the present day of the radical treatment of hernia."—Bassini, 1600

OPERATIVE treatment is indicated in the great majority of hernias and if due regard is paid to the choice of anæsthesia and operative technique it may be advised with confidence in its immediate safety and final result The operations now in vogue are for the most part standardised and are not difficult to carry out—and yet the disquieting fact remains that the recurrence rate in all forms of hernias is still far too high It must be emphasised therefore that to ensure maximum success they must be performed carefully unhurriedly and not entrusted as is commonly the practice to the inexperienced in surgery

Trusses have their place in the management of hernia but the rôle they play is a minor one Their use should be reserved for patients in whom the operative treatment is contraindicated A truss is a mechanical prop and often an uncomfortable one it never cures a hernia and does not obviate the risk of strangulation unless it fits well and is worn continuously

Treatment by injection of sclerosing fluids a method designed to control the hernia by inducing reactive fibrosis has been recommended by a few surgeons as an alternative to operation for certain types of *hernia but it is not reliable and has not gained general favour*

Operation is contraindicated in bad risk cases and where the technical difficulties in its performance seem likely to involve special risk or impair the prospects of curing the rupture For example the operation for a large umbilical or incisional hernia containing matted coils of bowel which may be quite a formidable procedure should not be undertaken if the patient is in poor condition Similarly operation should be *advised only after balancing carefully the benefits to* be expected against the risks to be run in patients suffering from affections predisposing to recurrence of the hernia such as chronic bronchitis or enlargement of the prostate with dysuria In such cases the type of hernia and the condition of the abdominal musculature must also be taken into account For example an oblique inguinal hernia may sometimes be repaired in circumstances in which a direct inguinal hernia is better left untreated an incisional hernia may be submitted to operation if the musculature is well developed but not if it is atonic. Occasionally the mere immensity of the hernia, with the consequent difficulty of returning the massive contents to the abdominal cavity may prove a bar to operation

The technique of operation varies according to the type of hernia and the musculature of the abdominal wall, but in general it aims at two main points (a) exposure and removal of the sac (b) reinforcement of the abdominal wall at the site of the hernia To this general rule, however there are exceptions For example in the indirect inguinal hernia in young subjects the removal of the sac alone suffices as there is usually no weakness in the musculature This procedure is called herniotomy or herniectomy In direct inguinal hernia in elderly subjects on the other hand the sac may be a mere bulging of the peritoneum and should not be excised here the repair or herniorrhaphy of the weak abdominal wall is all important To the operative principles mentioned yet a third may be added namely reconstruction of the inguinal sphincter It is applicable to the intermediate group that have a stretched deep ring and muscles which are still good

INGUINAL HERNIA

Inguinal Hernia in the Infant

A hernia present at birth or appearing in the first few months of life is attributable to failure in the normal process of obliteration of the processus vaginalis Sir Arthur Keith has stated that 4 4 per cent of male infants have an inguinal hernia in the first year of life and that of these one third undergo a natural cure by the fourth month Accordingly it often suffices to support the hernia either by an improvised truss conveniently made of a skein of wool or by a specially designed truss of rubber If this treatment fails and in all hernias in older infants operation should be advised An aggravating condition such as phymosis should be sought and dealt with. The only pre-operative preparation required is to omit the morning feed on the day of operation and to give an enema

An incision about 1 in long is made over the pubic spine the skin being stretched between thumb and forefinger The bleeding ends of the pudic vessels are picked up by hæmostats but not tied at once because by elevating the forceps the prepubic fat a thick layer in the child can be incised with precision down to the external ring The external spermatic fascia the cremasteric muscle and the internal spermatic fascia are picked up in turn and divided outside the inguinal canal until the white margin of the sac itself comes into view

The sac is then dissected free and carefully opened at the fundus with scissors or knife The identity of the sac can be established and its patency tested by introducing a probe The sac is now stripped of its coverings by means of dry gauze dissection assisted by a few touches with the knife The vas deferens a firm cord lying posteriorly is sought and identified and is wiped aside off the sac along with the spermatic vessels and investments The appearance of a lobule of extraperitoneal fat is an indication that the clearance is completed it signalises the presence of the bladder which in infancy is virtually an abdominal viscus.

The contents of the sac must now be examined and returned to the abdominal cavity The sac is then transfixed at its neck ligated and

removed To obviate the risk of transfixing a loop of bowel at the neck the sac may be twisted on itself before the stitch is introduced Occasionally if there are extensive adhesions of bowel to the sac, or if as is common in females the suspensory ligament of the ovary lies within it the sac may be ligated at a more distal point and reduced *en masse*

In hernia of *complete vaginal type* where the sac is continuous with the tunica vaginalis the sac should be divided as usual after transfixion and ligation at its neck and again a short distance above the testis the intermediate portion being removed The tunica vaginalis may be left open or may be closed by suture or the tunica may be stitched behind the testis after the manner adopted in the treatment of hydrocele

The *encysted* or *infantile* type also deserves special mention It is found in those cases where the closure of the vaginal process has occurred not at the upper pole of the testis but within the inguinal canal The hernial sac in its descent may either invaginate the tunica vaginalis or pass down behind it Thus it sometimes happens that three layers of peritoneum must be traversed before the lumen of the sac is entered

When the structures of the cord have been returned into the depths of the wound and the testis restored to the scrotum without any twist in the cord the skin incision is closed with fine silkworm sutures inserted rather deeply through the subcutaneous fat The small dressing is sealed by a sheet of adhesive plaster to prevent contamination from the napkin

Obstructed Inguinal Hernia in the Infant

An obstructed inguinal hernia in infancy can usually be treated conservatively If a sedative such as chloral hydrate is given and the child placed with its buttocks elevated on a pillow the hernia generally undergoes spontaneous reduction or may be reduced by manipulation If this fails taxis is repeated with the child suspended by the ankles—the Judgment of Solomon position Finally taxis should be attempted under anaesthesia

If these measures fail operation must be advised The dissection is carried out in the manner described above but inflammatory oedema renders definition of the individual structures difficult Generally the obstructing agent is found to be the external ring and this must be divided to allow the hernial contents to be reduced

Oblique Inguinal Hernia in the Adolescent and Adult

It is estimated that about 25 per cent of all inguinal hernias arise before the age of fifteen years In healthy adolescents and adults operative treatment should not be delayed for the rupture increases in size in some quicker than in others depending on the patients activities at work or in the field of recreation Early operation prevents undue stretching of the margins of the deep inguinal ring and atrophy of the inguinal sphincter thus improving the chances of a successful repair it also rids the patient of the ever present danger of

strangulation Except as a temporary measure, a truss is to be deprecated because the resulting compression atrophy of the inguinal tissues leaves the surgeon poor material to work on

The principles underlying the operative treatment for inguinal hernia are based on consideration of the mechanism by which nature guards this potentially weak region of the abdominal wall Keith's conception that the defence mechanism is dependent principally on a neuro muscular reflex rather than an unyielding barrier of fascia or aponeurosis is now universally accepted The manner in which it operates is most conveniently observed when as the result of imperfect anæsthesia the patient coughs or strains during the operative exposure of the inguinal canal

The contraction of the external oblique muscle is then seen to impart a high degree of tension to its aponeurotic sheet The arching fibres of the internal oblique muscle and the conjoined tendon function like a shutter or sphincter by contracting down on the spermatic cord and the inguinal ligament The closest analogy is the movement of the upper eyelid The obliquity of the canal itself is a safeguard because increased intra-abdominal pressure apposes firmly the posterior and the anterior walls of the canal Finally the retracted cremaster muscle contributes by elevating the testicle and partially plugging the external ring

As to the rôle of the internal or deep ring there is no general agreement Some say that it plays a purely passive one Others believe that the fascia transversalis is condensed at its pillars so as to form a U-shaped sling for the cord, which has its attachments to the deep aspect of the transversus muscle and that the effect of contraction and descent of this muscle along with the internal oblique is to stiffen the supporting fascial sling

Choice of Operation —A multiplicity of operative procedures has been described and since there is no unanimity as to choice of procedure the surgeon must use his personal judgment and adjust his technique according to the particular needs of the case However the following general principles may be advanced as a guide

(1) In patients with well-developed musculature especially adolescents and young adults the operative technique should be designed to maintain and restore the defence mechanism Thus the integrity of the external oblique must return to its original state the sphincter action should be assured, the obliquity of the canal retained and the contractibility of the cremaster preserved.

(2) In patients with less well-developed musculature the measures adopted after the sac has been removed, depend on the competence of the inguinal sphincter and the condition of the posterior inguinal wall. If restoration of the normal anatomy is considered worth while conservative measures such as narrowing the deep inguinal ring and plication of the transversalis fascia are all that need be attempted The modern methods of reconstructing the inguinal sphincter have a place in this type which requires further re-enforcement Thus the aim may be to strengthen the attachment of the conjoint tendon to the pectineal surface of the pubis and Cooper's ligament or again

ANATOMICAL KEY

Inguinal Canal.

Length.—1½ in.

Floor.—The inguinal ligament and its pectineal extension, *viz.* the lacunar ligament.

Anterior Wall.—(1) The external oblique aponeurosis throughout the whole extent of the canal and (2) the internal oblique muscle in the lateral half. Note that the latter arises from the lateral two-thirds of the inguinal ligament (see diagram below).

Posterior Wall.—(1) The fascia transversalis in the entire length; (2) the conjoint tendon in the medial half and; (3) the *reflected part of the inguinal ligament* when present in the medial fourth.

Roof.—The arching fibres of the internal oblique muscle.

Deep Inguinal Ring is a circular opening in the fascia transversalis situated midway between the anterior superior iliac spine and the symphysis pubis, *i.e.*, the mid-inguinal point.

It transmits.—(1) The spermatic cord.
(2) The cremasteric vessels (from the deep epigastric).
(3) The genital branch of the genito-femoral nerve (motor to the cremaster).
(4) The fibrous vestige of the processus vaginalis.

Superficial Inguinal Ring overlies the pubic crest and tubercle. It is really triangular in outline and transmits the cord and the terminal twigs of the ilio-inguinal nerve (*sensory*).

Coverings of the Cord.—(1) Internal spermatic fascia from the fascia transversalis; (2) the cremaster muscle derived from the internal oblique as it crosses in front of the cord laterally; and (3) the external spermatic fascia, an extension of the external oblique aponeurosis given off at the superficial ring.

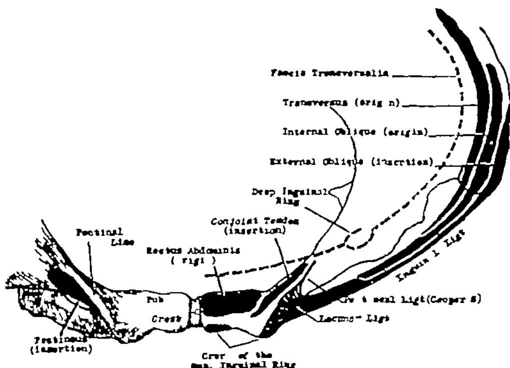


Fig. 230

Pelvis viewed from above to show the attachments of the structures concerned in the formation of the inguinal canal.

sutures or by the use of non absorbable material such as cotton silk, nylon steel wire or even a whole skin graft Rarely in an elderly man with very atrophic tissues and a large hernia is it justifiable to cut the cord across in order to obliterate the deep ring as well as the inguinal though this is said not to cause complete atrophy of the testicle

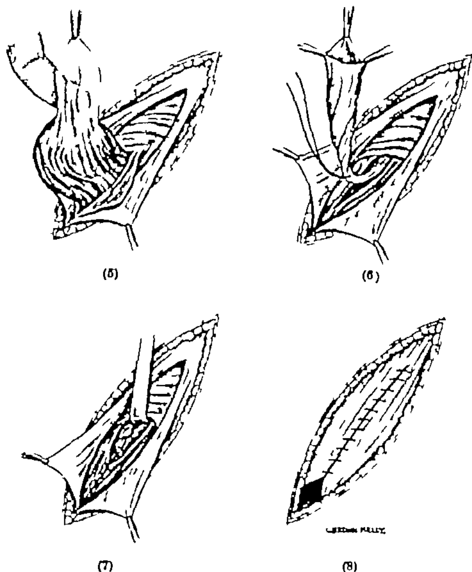


Fig 261

Inguinal hernia: simple herniotomy (5) Sac being dissected out of cord. (6) Sac opened and emptied, twisted and about to be ligated. (7) Sac excised, cremaster being sutured. (8) Aponeurosis sutured.

Choice of Anæsthesia—Inhalation anæsthesia generally nitrous oxide oxygen and ether is customary for routine use In elderly patients subject to bronchitis cyclopropane should be substituted or, if preferred unilateral spinal anæsthesia may be used. In bad risk ' cases local anæsthesia is of special value

The technique of local anæsthesia is as follows Using 1 per cent procaine hydrochloride (planocaine) three subcutaneous wheals are raised (*a*) at a point about an inch medial to the anterior superior spine (*b*) at the saphenous opening (*c*) at the external ring

A 3½ in needle is inserted through the first to infiltrate the intra muscular planes thereby blocking the ilio inguinal ilio hypogastric and last dorsal nerves At the second, the tissues below the inguinal ligament and at the base of the scrotum are infiltrated to block the pudic and genito-femoral nerves At the third the anæsthetic is injected towards the midline to the neck of the scrotum, and laterally in the vicinity of the inguinal canal A continuous line of subcutaneous injection is placed around the whole area connecting the initial points Finally the line of the skin incision is infiltrated

Simple Herniotomy—It is customary to make an incision 3 or 4 in long placed 1 in above and parallel to the medial side of the inguinal ligament The natural skin crease runs more horizontally and if its direction is followed a neater scar results (Fig 260) The superficial epigastric and external pudic vessels are divided between hæmostats and the wound is deepened through the fasciæ of Camper and Scarpa until the glistening fibres of the external oblique aponeurosis are seen

The external ring is then identified and made the starting point of the incision in the aponeurosis (Fig 260) The edges of the aponeurosis are pulled aside to expose the arching fibres of the conjoint muscle The ilio inguinal nerve which courses over the internal oblique muscle and the cremaster is lifted and held aside Some surgeons rather than run the risk of post-operative neuritis cut the nerve at this stage

The sac is found after dividing the cremaster and the internal spermatic fascia It is then stripped as far as the internal ring its neck securely tied by a transfixion-stitch and the tissue beyond cut away Often the cremasteric branch of the deep epigastric artery hinders the proper clearance of the neck of the sac This vessel should be sought medially and divided between ligatures Needless to say when divesting the sac of its coverings, the integrity of the vas deferens must be preserved and any bleeding points in the pampiniform plexus secured.

The cord is now replaced in its bed and the gap in the cremaster fibres loosely stitched over The aponeurotic flaps are next brought together and preferably double breasted. How wide the new external ring should be is a matter for individual judgment Closure of the skin wound is technically easier if the cut edges of Scarpa s fascia not the skin edges are picked up by the dissecting forceps while the skin sutures are being inserted.

Oblique Inguinal Hernia in the Female occurs when the canal of Nuck remains patent About 50 per cent of all hernias in women are inguinal as against 90 per cent in men Separation of the sac which is usually friable from the round ligament is a difficult manœuvre but success should attend patient perseverance Failure necessitates including the ligament in the transfixion stitch and removal of its distal portion along with the sac This conjoint stump will require to be tacked to the margin of the internal ring in order to maintain the support of the uterus and also to prevent the separation and retraction of the cut ligament away from the sac ligature

Narrowing of the Deep Ring—This is recommended after the sac has been dealt with in most adults operated on for indirect hernias

The internal oblique and transversus muscles are cut upwards and outwards at the point where the cord emerges from the deep ring The cord is pulled out to the lateral limit of the space thus formed and the edges of the muscles sutured

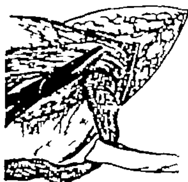


Fig 263

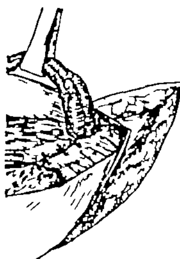


Fig 264

Fig 263.—The Brandon manœuvre first stage Snipping the lower edge of the internal oblique as it crosses the internal ring

Fig 264 —The Brandon manœuvre second stage The cord has been displaced upwards into the internal oblique and the edges of the cut muscle fibres reunited underneath.

together on the inner side of the cord As an additional step suture of the conjoined tendon to Cooper's ligament rather than the Bassini repair is recommended

Extra-aponeurotic Displacement of the Cord.—This procedure described by Halsted may be conveniently used in conjunction with plication of the fascia transversalis and is most satisfactory in the treatment of hernias of moderate size where the musculature is defective It is also used for direct hernia (*Fig* 268)

When the canal has been opened and the sac is dealt with as described under Simple Herniotomy the cord is drawn out of the wound The upper leaf of the external aponeurosis is pulled down behind the cord and fixed to the deep surface of the inguinal ligament by catgut or fine silk sutures The lower leaf of aponeurosis is also taken behind the cord so as to overlap the upper and there sutured in place To avoid *constriction of the cord the rigid margin of the lower flap* should be nicked at the level of the internal ring The cord now issues at the internal ring directly into the subcutaneous layer but no ill-effects result from this displacement In the Willys-Andrews modification the cord is accommodated between the two leaves of the aponeurosis but this arrangement is apt to constrict the veins of the pampiniform plexus and affect testicular function

Repair by Aponeurotic Suture.—In this method originally described by McArthur strips of the tendinous portion of the external oblique are detached and used as sutures which are laced or darned across the defective posterior wall of the canal When the canal has been opened and the sac *dealt with the incision in the external oblique* is extended upwards and laterally almost to the anterior superior spine

and a second incision is made in it parallel to and about ½ in above the first. The intervening strip is freed at its lateral end but left attached to the pubis at its medial end. A similar strip is borrowed from the lower flap and this one is left attached to the lateral edge of the primary incision in the aponeurosis. The free ends threaded on large-eyed needles of the Gallie pattern are used to make a loose darn between the conjoint muscle and tendon and the inguinal ligament. The outer suture may be carried round the under surface of the cord in order to constrict the deep ring and finally secured as described below. The flaps of the external oblique are then stitched together.

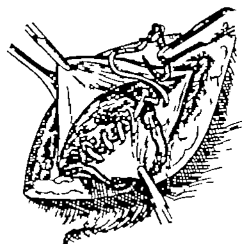


Fig. 265

Fascia lata graft for repair of inguinal hernia. The first row of the continuous suture completed. Suture now carried medially with a wide traverse.

Repair by Gallie's Fascia Graft.—If in a large hernia with defective musculature the external oblique aponeurosis is too thin or frayed to provide a suture, recourse should be had to a free fascia graft, which may conveniently be taken from the fascia lata of the thigh.

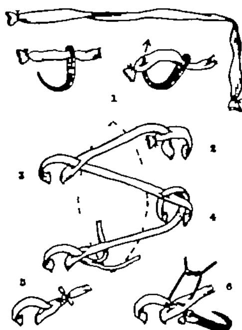


Fig. 266

The different points in technique in using fascial suture (after Gallie): (1) Method of attaching Gallie needle. (2) Anchoring suture. (3) and (4) Locking suture. (5) Terminating suture by knotting split end. (6) Terminating suture by oversewing with silk.

The *graft* is obtained by one of two ways:—

1. A small transverse incision is made on the lateral aspect of the thigh immediately above the femoral condyle and deepened to expose the fascia lata. A short tongue of the fascia is then dissected up, introduced through the ring head of a special long-shafted stripper and held by hæmostats. The stripper is then pushed forcibly upwards towards the great trochanter separating a strip of fascia lata about 10 in long and ½ in broad. The proximal end of the strip may be detached by manipulating the stripper or may be exposed and divided through a second small incision.

2. Some surgeons are averse to this method because it is liable to be followed by pain or even herniation of the vastus lateralis. The alternative is to make a long incision on the anterolateral aspect of the thigh and remove a

length of fascia Thereafter the rent is closed by a continuous catgut stitch

A fine silk transfixion suture is then applied to each end of the strip to prevent fraying and the strip is threaded through a large-eyed needle as shown in Fig 260 The strip is then used like the aponeurotic strip described to lace across the posterior wall of the canal and in addition it may be used to secure closure of the gap in the external oblique aponeurosis in front of the cord Finally the end of the fascial strip is anchored to the penultimate loop of the suture or to the external oblique aponeurosis by several fine silk stitches

The disadvantage of the aponeurotic and fascial darns is that they are prone to lacerate the inguinal ligament badly To minimise the ribboning effect the sutures should be taken through the ligament at different planes and should never at any time be drawn tight If Poupart s ligament is too readily frayed the less yielding fibres of Cooper s ligament can be utilised instead Otherwise the fascial sutures are well received It has been shown by animal experiment that the innermost cells of the graft remain viable and once the young connective tissue has formed and filled the gaps and chinks of the lattice the end result is a firm sheet of fibrous tissue

Repair by Non-absorbable Sutures.—There is little to choose between silk cotton nylon stainless steel or tantalum wire Their value lies not so much in their strength as in the connective tissue response which their presence evokes With catgut there is always a local leucocytic and giant-cell infiltration which lingers until absorption is complete With silk the immediate cellular reaction is less intense and ultimately the suture becomes buried in fibrous tissue With steel or tantalum the fibrosis occurs in the absence of any inflammatory reaction Furthermore being a single filament and heat sterilised there is little risk of introducing infection when using the metal sutures

The stitch is in the form of a series of loose loops carried to and fro in criss-cross fashion and stitches between the ligaments of Poupart Gimbernat and Cooper on the one hand and the conjoint muscle and tendon on the other It is advisable to take the most medial stitch through the rectus sheath and the periosteum of the pubic spine and to fortify the deep ring laterally

Special points concerning the use of metal sutures —The wire is threaded through an ordinary needle the short end being twisted round the other several times before starting to sew Needles of the atraumatic type are also available The stitch is begun at the medial end (*vide supra*) and anchored by a reef knot The short end is cut flush with the knot preferably with an old pair of scissors reserved for the purpose The filament is very liable to form a kink which impedes each pull through The assistant can avoid this by keeping a loose hold of the wire and catching it again as it is drawn through The stitch finishes as it began with a reef knot

Repair with Whole-Skin Graft.—The foregoing methods of radical repair depend for their efficiency largely on the connective tissue response of the host tissues It has recently been shown that a whole skin graft when buried, loses its dermal and epidermal elements and

becomes converted into a layer of collagen and elastic tissue The method is still on trial

Briefly the technique is as follows —An oval of well prepared skin about 2 in long and 1 in wide is excised from the inguinal region denuded of its subcutaneous fat and laid across the posterior wall of the inguinal canal The graft is stitched to the rectus sheath the lower edge of the conjoint structures and Poupart s ligament and by slitting the outer edge of the graft the cord can be encompassed with skin as it emerges from the deep ring

Post-operative Care. See p 563

Strangulated Inguinal Hernia

In a case seen shortly after strangulation has occurred—that is within two or three hours—an attempt may be made to reduce it by taxis The foot of the bed is raised and the hip is flexed to relax the abdominal muscles While the neck of the hernia is steadied between the fingers of the one hand, gentle pressure is then exerted upon the fundus of the sac with the other hand. Attempts to reduce a hernia should always be made with great gentleness and should never be made if the strangulation has been present more than a few hours If the attempt appears to have been successful the possibility of reduction *en bloc* should be borne in mind and if the symptoms are not immediately relieved, operation should be performed without delay. If proper reduction has been achieved it is generally wise to operate within a few days to prevent recurrence

Generally when the patient is first seen it is clear that operative treatment is necessary In such cases the pre-operative measures advised for other forms of intestinal obstruction must always be carried out (p 595) A spinal or local anæsthetic should generally be chosen

The operative technique is similar to that of the interval procedure with the modifications necessary to deal with the strangulated loop The inguinal canal is opened by incising the external oblique aponeurosis and the pillars of the subcutaneous inguinal ring and the sac is exposed by dividing the coverings of the cord The tense fundus of the sac is then nicked between hæmostats to give exit to the pent-up fluid collection which since it may be infected is mopped up with care The opening is then exposed up to the neck of the sac

The constricting agent must now be released. Generally the fibrous neck of the peritoneal sac is responsible and it must be divided with great care to avoid damage to the strangulated loop which being distended is very liable to injury The fibrous ring may be divided by a bistoury introduced blindly through the neck—the intestines being protected by a grooved dissector—but a better method is to draw the whole sac gently downwards and cut through the neck by scissors introduced under direct vision.

When the constriction has been relieved the strangulated loop is drawn out at the wound and inspected to determine its viability with special attention to the two constriction rings Viable intestine

length of fascia Thereafter, the rent is closed by a continuous catgut stitch

A fine silk transfixion suture is then applied to each end of the strip to prevent fraying and the strip is threaded through a large-eyed needle as shown in Fig 266 The strip is then used like the aponeurotic strip described to lace across the posterior wall of the canal and in addition it may be used to secure closure of the gap in the external oblique aponeurosis in front of the cord Finally the end of the fascial strip is anchored to the penultimate loop of the suture or to the external oblique aponeurosis by several fine silk stitches

The disadvantage of the aponeurotic and fascial darns is that they are prone to lacerate the inguinal ligament badly *To minimise the ribboning effect* the sutures should be taken through the ligament at different planes and should never at any time be drawn tight If Poupart s ligament is too readily frayed the less yielding fibres of *Cooper s ligament can be utilised instead Otherwise the fascial* sutures are well received It has been shown by animal experiment that the innermost cells of the graft remain viable and once the young connective tissue has formed and filled the gaps and chinks of the *lattice the end result is a firm sheet of fibrous tissue*

Repair by Non absorbable Sutures.—There is little to choose between silk, cotton nylon stainless steel or tantalum wire Their value lies not so much in their strength as in the connective tissue response which their presence evokes *With catgut there is always a local* leucocytic and giant-cell infiltration which lingers until absorption is complete With silk, the immediate cellular reaction is less intense and ultimately the suture becomes buried in fibrous tissue With steel or tantalum *the fibrosis occurs in the absence of any inflammatory* reaction Furthermore being a single filament and heat sterilised there is little risk of introducing infection when using the metal sutures

The stitch is in the form of a series of loose loops carried to and fro in criss-cross fashion and stitches between the ligaments of Poupart Gimbernat and Cooper on the one hand and the conjoint muscle and tendon on the other It is advisable to take the most medial stitch through the rectus sheath and the periosteum of the pubic spine and to fortify the deep ring laterally

Special points concerning the use of metal sutures —The wire is threaded through an ordinary needle the short end being twisted round the other several times before starting to sew Needles of the atraumatic type are also available The stitch is begun at the medial end (*vide supra*) and anchored by a reef knot The short end is cut flush with the knot preferably with an old pair of scissors reserved for the purpose The filament is very liable to form a kink which impedes each pull through The assistant can avoid this by keeping a loose hold of the wire and catching it again as it is drawn through The stitch finishes as it began with a reef knot

Repair with Whole-Skin Graft.—The foregoing methods of radical repair depend for their efficiency largely on the connective tissue response of the host tissues It has recently been shown that a whole skin graft when buried loses its dermal and epidermal elements and

becomes converted into a layer of collagen and elastic tissue The method is still on trial

Briefly the technique is as follows —An oval of well prepared skin about 2 in long and 1 in wide is excised from the inguinal region denuded of its subcutaneous fat and laid across the posterior wall of the inguinal canal The graft is stitched to the rectus sheath the lower edge of the conjoint structures and Poupart s ligament and by slitting the outer edge of the graft the cord can be encompassed with skin as it emerges from the deep ring

Post-operative Care See p 563

Strangulated Inguinal Hernia

In a case seen shortly after strangulation has occurred—that is within two or three hours—an attempt may be made to reduce it by taxis The foot of the bed is raised and the hip is flexed to relax the abdominal muscles While the neck of the hernia is steadied between the fingers of the one hand, gentle pressure is then exerted upon the fundus of the sac with the other hand Attempts to reduce a hernia should always be made with great gentleness and should never be made if the strangulation has been present more than a few hours If the attempt appears to have been successful, the possibility of reduction *en bloc* should be borne in mind, and if the symptoms are not immediately relieved, operation should be performed without delay. If proper reduction has been achieved it is generally wise to operate within a few days to prevent recurrence

Generally when the patient is first seen it is clear that operative treatment is necessary In such cases the pre-operative measures advised for other forms of intestinal obstruction must always be carried out (p 595) A spinal or local anæsthetic should generally be chosen

The operative technique is similar to that of the interval procedure, with the modifications necessary to deal with the strangulated loop The inguinal canal is opened by incising the external oblique aponeurosis and the pillars of the subcutaneous inguinal ring and the sac is exposed by dividing the coverings of the cord The tense fundus of the sac is then nicked between hæmostats to give exit to the pent-up fluid collection which since it may be infected, is mopped up with care The opening is then exposed up to the neck of the sac

The constricting agent must now be released Generally the fibrous neck of the peritoneal sac is responsible and it must be divided with great care to avoid damage to the strangulated loop which being distended is very liable to injury The fibrous ring may be divided by a bistoury introduced blindly through the neck—the intestines being protected by a grooved dissector—but a better method is to draw the whole sac gently downwards and cut through the neck by scissors introduced under direct vision

When the constriction has been relieved the strangulated loop is drawn out at the wound and inspected to determine its viability with special attention to the two constriction rings. Viable intestine

may be of normal hue or plum-coloured but it retains its peritoneal sheen and its contractility Non viable intestine is grey in colour matt surfaced and flaccid while in late cases the mesenteric vessels do not pulsate When the viability is in doubt hot saline packs should be applied for five minutes to see if the loop recovers its tone If spinal anæsthesia is being used the peristaltic contractions may be followed down to the affected loop if they are arrested the loop should be regarded as non viable Finally valuable evidence is obtained by administering pure oxygen by means of a face mask for if the bowel is viable it rapidly regains a healthy pink colour

If the bowel is viable it is returned to the abdomen and the canal may be repaired as in the interval operation If a narrow constriction ring is non viable it may be invaginated (Fig 292) If a large segment is non viable the choice lies between resecting the affected loop and bringing it out to the surface (exteriorisation) the latter method is the less dangerous and is to be recommended in bad risk cases (p 606)

The after treatment is similar to that for other forms of intestinal obstruction

Direct Inguinal Hernia

Since direct inguinal hernia occurs commonly in elderly men with defective abdominal musculature since the hernia commonly is a mere bulging of the abdominal parietes causing little discomfort and since there is little risk of strangulation the indications for operation are less emphatic than in oblique inguinal hernia and many patients are better treated by means of a well fitting truss

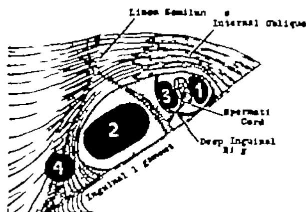


Fig 207

Diagram illustrating sites of the different inguinal herniæ The aponeurotic layer has been removed (1) Indirect herniæ (2) The common direct herniæ (2) and (3) Pantaloon herniæ (4) Hernia through the linea semilunaris.

The operation for direct hernia differs from that for oblique hernia in respect that the peritoneal sac requires less attention while the repair of the canal requires more The incision and access however and the general methods of reinforcement are the same

The *peritoneal sac* which bulges through Hesselbach s triangle *i e.* medial to the deep epigastric artery does not require to be excised unless very large If it is excised, its neck cannot be closed by transfixion ligature but must be stitched like a laparotomy Great care must be taken to avoid damage to the bladder which is often incorporated in the medial wall of the sac *Pantaloon* or saddle-bag hernia is the descriptive names applied to the type of sac that protrudes on either side of the deep epigastric artery By dragging on the inner component

of the sac after the manner shown in Fig 261, the greater part of the sac can be delivered and excised. The Spigelian hernia is another special type It occurs through a localised weakness in the region of the linea semilunaris The sac is usually small and narrow necked

The *repair* of the canal in direct hernias must be more thorough than in the oblique variety Any of the methods described on the earlier pages may be used but since the musculature is defective the conjoint tendon atrophic and stretched and the external oblique aponeurosis thin and frayed the more thorough methods of reinforcement are generally to be advised The most difficult region to fortify is the inner angle for it is through this part that recurrences most commonly occur As a preliminary the cremaster should be excised along with any loose areolar tissue that may lie in the vicinity of Poupart s ligament The procedure shown in Fig 268 (2) and (3) is

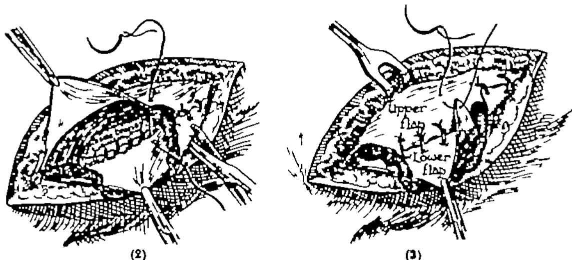


Fig 268

Direct inguinal hernia. ( ) Fascia transversalis plicated, upper edge of external oblique aponeurosis being sutured to deep aspect of inguinal ligament (3) Lower flap of aponeurosis, split to accommodate the spermatic cord, being overlapped.

advised, in which the posterior wall of the canal is strengthened first by plicating the fascia transversalis and secondly by overlapping the external oblique aponeurosis behind the cord. In cases in which the aponeurosis is too atrophic it is often advisable to make use of a fascia graft or other radical methods described.

Sliding Hernia

In large inguinal hernias especially of direct type the weighty protrusion may exert traction upon the peritoneal covering of the bladder and bowel and pull either or both these viscera down into close relationship with the neck of the sac

The presence of such a sliding hernia may be suspected when difficulty is encountered in freeing the neck of the sac from its coverings in the vicinity of the internal ring The proximity of the bladder is indicated by adhesions on the medial aspect of the ring and by a brisk venous ooze If the dissection is continued the interlacing muscle fibres of the bladder may be recognised The presence of bowel is

confirmed when the sac is opened on the right side the cæcum is seen lying mainly retroperitoneally on the left side the sigmoid colon, its short mesentery unfolded

If possible the displaced colon should be elevated from its retroperitoneal bed enveloped in a peritoneal covering, and thus mobilised

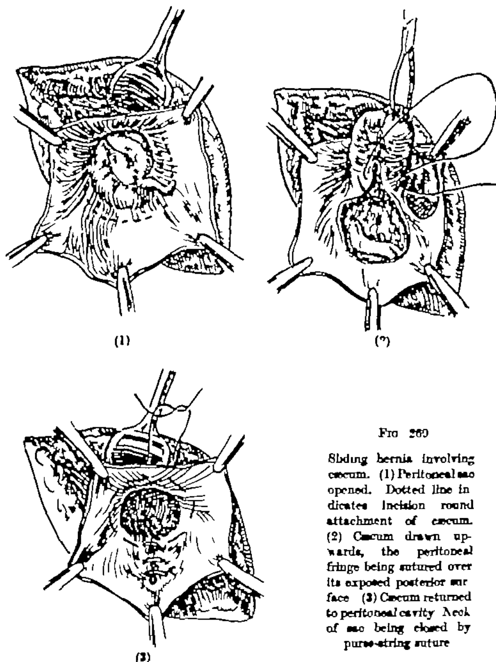


Fig 260

Sliding hernia involving cæcum. (1) Peritoneal sac opened. Dotted line indicates incision round attachment of cæcum. (2) Cæcum drawn upwards, the peritoneal fringe being sutured over its exposed posterior surface (3) Cæcum returned to peritoneal cavity Neck of sac being closed by purse-string suture

returned to the abdominal cavity This method is most readily applicable to the cæcum The posterior part of the hernial sac is incised round the attachment of the cæcum bearing a fringe of peritoneum the cæcum is then elevated by dissection and the peritoneal fringe is turned back and sutured over the extensive raw area on its exposed posterior surface The remainder of the operation is then conducted in the usual way (see Fig 260)

If such a plastic procedure appears too formidable and especially if the bladder is involved the alternative method should be adopted The fundus of the hernial sac is excised and the peritoneum closed by a continuous suture The remainder of the sac along with the bladder and bowel is then gently displaced back into the abdominal cavity *en masse* Particular care is then required in reconstituting the abdominal wall especially in the lateral part of the inguinal canal, which is the weak point in this type of hernia A valuable method is that indicated in Fig 208 in which the fascia transversalis is plicated and the canal is obliterated by suturing the external oblique aponeurosis down to the inguinal ligament the lower flap of aponeurosis split to accommodate the cord being overlapped

FEMORAL HERNIA

Essentially a femoral hernia passes under the same muscular arch as does an inguinal hernia but the pathway which it follows is guarded not by a sphincter arrangement but by the ligaments of Poupart Gimbernat and Cooper On the lateral side the bulging wall of the femoral vein may also offer some resistance to the descent of a potential sac The hernia rarely appears before the age of twenty years which suggests that the majority are acquired The predisposing conditions are pregnancy, obesity, emaciation.

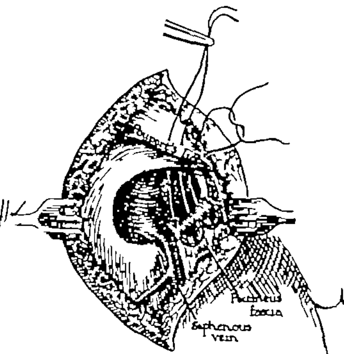


Fig 210

The femoral approach. Sutures inserted to obliterate femoral canal by approximating inguinal ligament to pectineus fascia.

Since a femoral hernia cannot be controlled adequately by a truss and is very liable to the dangerous complication of strangulation operation should be advised in all but aged and debilitated patients

The femoral hernia is a product of a less complex mechanism than is the inguinal hernia consequently its surgical management is a comparatively simple problem and the varieties of operative procedure practised are few

The principles of operation, as for other hernias, are to expose and remove the sac and repair the defect in the abdominal wall and the femoral canal The variations in technique concern the route of access to the canal and the methods to be employed to occlude it Two main

types of procedure are employed the low operation and the high operation In each the sac is exposed first at the fossa ovalis In the low operation after the sac has been excised the canal is closed at its lower end in the high operation the neck of the hernial sac is exposed above the inguinal ligament after laying open the inguinal canal and the femoral canal is then closed at its upper end The inguinal approach is to be preferred as the sac can be ligated right at its neck and the closure of the canal can be performed more effectively

Low Operation—A vertical or oblique curved incision is made starting above the inguinal ligament and passing over the hernial protrusion at the base of the femoral triangle The wound is deepened through the superficial fascia until the oblique fibres of the external oblique aponeurosis are exposed above and the fundus of the hernia below

To expose the hernial sac as it lies in the fossa ovalis it is necessary to divide and reflect its coverings the cribriform fascia and the extra peritoneal fat and lymphoid tissue derived from the septum femorale Often it is not easy to distinguish these various layers and the difficulty is increased by the fact that the fundus of the sac is wrapped in adherent fat which may resemble a lipoma The narrow neck of the sac however is devoid of fat and can be defined as it emerges from the femoral canal

The next step is to open the fundus of the sac which is held up in hæmostats to avoid damage to any contained viscus The sac generally contains omentum which is often adherent and sometimes a loop of small intestine Adhesions are freed redundant omental tags may be excised and the contents are returned to the abdominal cavity The sac is then drawn downwards twisted gently ligated by a transfixion stitch and divided the stump being allowed to retract upwards into the femoral canal

Closure of the canal is rendered difficult by the rigid nature of its anterior posterior and medial walls and the proximity of the femoral vein to the lateral wall Methods formerly in use such as tacking the inguinal ligament to the pubic bone by a metal staple or a bone traversing stitch are now obsolete Some surgeons make no attempt to close the canal or simply occlude it by retaining the hernial sac, bunching it up by sutures and stitching it to the anterior and posterior walls of the canal Others attempt to secure closure by suturing the inguinal ligament to Cooper s fascia (the thickened portion of the pectineus fascia (see Fig 270)) or by turning a flap of the latter structure forwards across the canal

High Operation—The incision advised for the low operation may be used or an oblique one above the inguinal ligament The wound edges are undermined in a plane deep to Scarpa s fascia so as to provide access to both the hernial protrusion and the inguinal canal. The fundus of the sac is then divested of its coverings in the manner described for the low operation and dissected free up to its point of emergence from the femoral canal.

To gain access to the neck of the sac at the upper end of the femoral

canal the inguinal canal is opened in the same way as for inguinal hernia splitting the external oblique aponeurosis The round ligament or spermatic cord is then displaced and the transversalis fascia incised to expose the extra peritoneal fat By blunt dissection the sac can now be exposed as it enters the femoral canal and hooked up thus dragging the rest of the sac through the femoral canal In this way the sac can be followed up to its parent peritoneum and ligated there

The femoral canal can now be closed at its upper end The method most commonly practised is to suture the conjoint tendon to Cooper's ligament but this has been criticised on the grounds that the stitches tend to cut out and the inguinal canal is weakened The most effective closure is obtained by using a strip of external oblique aponeurosis fashioned from the upper margin of the inguinal incision The medial end is left attached to the pubis The lateral end is freed and threaded on to a *Gallie* needle and the strip is then darned across the femoral canal between the inguinal ligament and the pectineus fascia and muscle (Fig 271) The external iliac vein must be guarded by the forefinger while this is being done Finally the anterior and posterior walls of the inguinal canal are reconstituted by sutures and the wound is closed

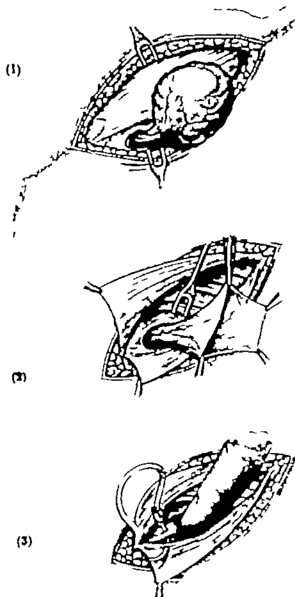


Fig 271

Femoral hernia. The high operation. (1) The sac exposed and defined. (2) External oblique aponeurosis incised to expose inguinal canal the sac, emptied and transposed, now brought out through fascia transversalis. (3) Suture from upper edge of aponeurosis held in Gallie needle being inserted through pectineus fascia and inguinal ligament

Strangulated Femoral Hernia

Owing to the small size and rigid nature of its canal a femoral hernia is especially liable to strangulation with the risk of early necrosis of the contained intestine The condition is a serious one and early operation should be advised without taxis, which is unlikely to be successful and is apt to inflict further damage to the bowel

The pre-operative preparation is the same as for other types of intestinal obstruction Spinal or local anæsthesia may be used

Access is gained as described above preferably by the inguinal approach When the sac is opened a quantity of turbid fluid is usually found and should be mopped out carefully as it may be infected To relieve the strangulation it is necessary to enlarge the femoral canal by dividing the lacunar (Gimbernat s) ligament This may be done by nicking it blindly by a guarded tenotome introduced along the canal from below but a better method which also obviates the possibility of injuring an abnormal obturator artery is to expose the ligament from above via the inguinal canal and divide it under direct vision In some cases the actual constricting agent is the narrow peritoneal neck of the sac and this also must be divided with great care to avoid damage to the contained intestine

Once the intestine is released it tends to retract within the abdomen but this must be prevented until the loop has been examined for viability (p 540) If the loop is viable it is returned to the abdomen the sac is removed and the operation continued as in the interval procedure If the loop is not viable it must be dealt with as described on p 604 If the loop can be drawn down sufficiently this may be done through the original incision but if as is usual the mesentery is too short to allow this to be done the abdomen must be opened through a paramedian incision in order to give better access

UMBILICAL HERNIA

Umbilical hernia may occur as a congenital deformity (exomphalos) it may develop shortly after birth or it may be acquired in adult life.

Congenital Umbilical Hernia

In this rare deformity at birth the umbilical cord is found to be distended and contain abdominal viscera prolapsed through the patent umbilical orifice In complete exomphalos the whole midgut loop may be involved and retain its fœtal position and relationships The cord is then greatly distended forming a mass of dull greyish appearance in which the coils of bowel are partly visible through the covering membranes Other congenital defects may coexist such as congenital atresia of the intestines while such complications as prenatal rupture of the membranes with evisceration add to the gravity of the condition

In partial exomphalos only a small segment of intestine is prolapsed and since the umbilical cord is not greatly distended there is a risk that the hernia may go unrecognised and the intestine be included in the cord ligature

Successful treatment depends upon prompt intervention for the cord membranes being deprived of blood supply after birth soon slough and fulminating peritonitis then ensues Operation should therefore be performed within twelve hours of birth Light ether anaesthesia may be used A circular incision is made at the junction of skin with foetal membranes round the umbilicus If necessary the incision is enlarged upwards or laterally—never downwards—to avoid damage to the bladder. The viscera are then returned to the abdomen and the defect is closed by strong silkworm gut sutures through the full thickness of the abdominal wall

Umbilical Hernia in Infants

This is a true hernia which develops in early infancy It consists of a peritoneal sac, usually of small size which emerges through a small orifice in the linea alba at the site of the organising umbilical cicatrix Since the cicatrix undergoes progressive contraction there is a marked tendency to spontaneous cure of the hernia The treatment in the first place therefore should be conservative The customary method is to apply a penny, covered with lint directly over the orifice and hold it in position by means of a strip of adhesive plaster A small swab folded up probably serves better than a coin. If excoriation of the skin or dermatitis results from the adhesive material a firm binder may be used the skin being treated with calamine lotion or with spirit followed by boric powder Any condition liable to cause persistent straining such as severe phimosis constipation, or diarrhoea, must be rectified Generally under this treatment the hernia is controlled and eventually is obliterated

A period of six months should usually be allowed before operative treatment is considered—some surgeons advise as long as a year or more—except in the rare cases in which strangulation supervenes If operation proves necessary the procedure is simple Under ether anaesthesia a short transverse incision is made above the umbilicus and the lower flap is undercut to expose the peritoneal sac which is then defined as it emerges through the linea alba A catgut ligature is then applied to encircle the neck of the sac, which is thus securely occluded It is not necessary to remove the sac, the fundus of which is firmly adherent to the skin cicatrix nor is it usually necessary to close the orifice in the linea alba If the orifice is large it may be occluded by a vertical overlap of the rectus sheath in the manner described for umbilical hernia in adults this can be done without sacrificing the umbilicus itself

Umbilical Hernia in Adults

Umbilical hernia occurs commonly in obese persons many of them elderly and subject to cardiac and pulmonary ailments Although they are thus often unsuitable subjects for surgery, operation is commonly necessitated by the discomfort and futility of conservative measures by progressive enlargement and irreducibility of the hernia or by the onset of obstruction and strangulation

The hernia starts as an evagination of extraperitoneal fat through a chink in the stretched linea alba and the protrusion thus started gradually enlarges. Since in contrast with other hernias the sac cannot increase in size by drawing on reserves of adjacent peritoneum (which is too closely adherent to the posterior rectus fascia) it tends to sacculate and become thinned out. Multiple rents thus appear and the spaces are filled by fibrous tissue replacement. Consequently the sac becomes loculated and closely attached to the overlying skin while the contents of the hernia—usually omentum and transverse colon with occasionally a loop of jejunum—often are fixed to the sac by dense adhesions. Fortunately the neck of the hernial sac is generally free from adhesions.

As the hernia becomes massive and dependent it assumes an ovoid outline transversely disposed and the umbilicus becomes more recessed and pulled out into a horizontal slit at the lower pole. In persons of careless habit infection readily supervenes in the umbilical recess and the field of operation is further complicated by erythema intertrigo as a result of chafing of skin surfaces.

Pre-operative Treatment—Unless acute obstruction is impending operative treatment should be postponed until the patient is in a fit state to withstand a major surgical undertaking. When possible the weight should be reduced by a prolonged course of dieting, and attention must be paid to any cardiac or pulmonary lesion. The bowels must be regulated with especial care owing to the constant involvement of colon in the hernial sac. Attention is directed to the local hygiene of the umbilicus and the intertriginous skin surfaces, the parts being cleansed by washing with soap and water and treated with methylated spirit and boracic powder. Local dusting with sulphathiazole may be a useful adjunct for resistant umbilical sepsis.

Anæsthesia—In interval cases inhalation or spinal anæsthesia may be chosen according to the fitness of the patient. In poor risk cases and where strangulation is present anæsthesia by local and regional infiltration is preferable. It is carried out by injecting 1 per cent procaine along the line of the incision round the base of the hernia and by a series of punctures along the lateral border of the rectus muscles to block the eighth to eleventh thoracic nerves.

Operation—Two long crescentic incisions are made embracing the hernia and an ellipse of skin. The wound is deepened all around through the fat until the shining aponeurosis of the anterior rectus fascia is exposed. A few vessels perforating the aponeurosis and bleeding points in the fat will require ligation at this stage to ensure complete hæmostasis.

Attention is now directed to the neck of the sac (which is most likely to be free of adhesions) and not to the fundus as in other types of hernia. The fibrous investments of the neck are nicked in turn by the knife until the peritoneum itself is opened sufficiently to allow the finger or a blunt dissector to be introduced. The opening may now be safely enlarged and the remainder of the circumference of the neck snipped with scissors. The hernial contents are then gently extricated from the loculated fundus but this may prove difficult owing to adherence of the contents. Omentum should be removed if

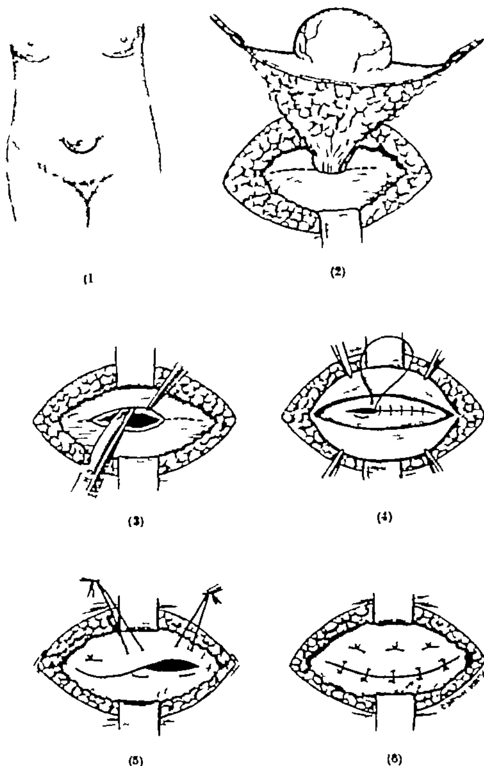


Fig 272

Umbilical hernia.

(1) Before operation. (2) Ellipse of skin and fat including sac freed down to point of emergence through linea alba. (3) The sac has been removed, opening in linea alba enlarged laterally and being freed from peritoneum (4) Continuous suture for peritoneum. (5) Lower aponeurotic flap drawn up by mattress sutures. (6) Repair completed

adherent or if too bulky to be returned to the abdomen The fundus with overlying skin and umbilicus can now be discarded and the freed contents replaced inside the abdomen where they are restrained by a large moist pack

The repair of the abdominal wall is best carried out by Mayo's method of horizontal overlap which has the advantage over a side-to-side overlap that its sutures are not subject to strain by the lateral pull of the oblique and transverse muscles

The parietal peritoneum is first undermined round the hernial aperture and closed by a continuous suture and the aponeurosis is then overlapped as shown in Fig 272 If necessary to secure satisfactory overlap the aponeurosis may be incised laterally into the rectus sheath on either side The flaps are sutured by silk or linen mattress sutures or if there is much tension by fascia sutures The skin is then closed To drain the large dead space left in the subcutaneous fat a small rubber tube or strip of dental rubber should be inserted at each end of the wound After the operation a tight binder should be applied

Post-operative Care See p 563

EPIGASTRIC HERNIA

An epigastric hernia is a small protrusion of extraperitoneal fat sometimes with a narrow peritoneal sac through the linea alba in or close to the midline an inch or two above the umbilicus It occurs commonly in young subjects and never reaches large size It may give rise to discomfort or even pain and to reflex dyspepsia but since the hernia contains no viscus there is no risk of obstruction or strangulation

Operative treatment is indicated if the pain is severe The hernia is exposed through a horizontal incision The protruding fat and sac are excised and the defect is repaired by overlapping the anterior rectus sheath as in the operation for adult umbilical hernia

INCISIONAL HERNIA

Incisional hernia occurs most commonly at the site of operation scars in the lower abdomen especially where the wound has been made through a weak portion of the abdominal wall or when suppuration has occurred Midline incisions below the umbilicus and appendicectomy incisions in the right lower quadrant are the two common sites

The hernia frequently is of large size emerges through a wide gap in the abdominal parietes and mushrooms widely in the subcutaneous tissue Its fundus lies immediately deep to and is adherent to the thin stretched cutaneous scar and contains a tangle of adherent bowel and omentum

The treatment may be palliative or operative Palliative treatment—supporting the hernia by a belt or corset—often suffices and is indicated especially where the hernia is small, reducible and symptom free or where it takes the form of diffuse bulging Operative treatment

is indicated where the hernia is large irreducible or giving rise to pain or other disability The operation for a large incisional hernia especially if in a stout elderly patient is a somewhat formidable procedure and not free from risk

An elliptical incision is made outlining the broad cutaneous scar and extending well beyond the two extremities of the hernia The incision should be made with care since the sac and adherent intestine may be *immediately deep to the skin* *The lateral skin edges* are then undercut and raised beyond the confines of the mass and only then deepened to expose the aponeurosis The dissection is then followed medially until the neck of the sac is exposed as it protrudes through the abdominal parietes

Great care is again required when the sac is opened to avoid damage to adherent intestine When possible adhesions of bowel should be separated the omentum if adherent or very bulky should be excised If adhesions are very dense it may be necessary to return the contents to the abdomen *en masse.*

Two methods are available for reconstituting the abdominal wall If the hernia is small and the muscularity adequate the various layers of the abdominal wall are defined by dissection and closed separately by sutures of catgut silk or linen thread. In some cases the layers may be overlapped as in the operation for umbilical hernia (Fig 272) If the hernia is large and the muscles atrophic, it is generally preferable to free the peritoneum and close it by a continuous catgut suture and to approximate the remaining fused layers by sutures of fascia or tantalum wire

DIAPHRAGMATIC HERNIA

The predisposing factors are faulty development of the diaphragm, an unduly wide œsophageal opening or trauma

The para-œsophageal type is the commonest The sac occupied by the upper part of stomach, enters the inferior mediastinum and passes behind the left pulmonary ligament As more of the stomach is drawn up it turns in its long axis and elevates the transverse colon Occasionally the lower end of the œsophagus is forced up with the cardia thus giving rise to a picture that is difficult to distinguish radiologically from that of a true short œsophagus The commonest of the congenital group is a hernia through the pleuro-peritoneal (Bochdalek's) canal the gap which sometimes persists between the vertebral and costal elements of the diaphragm When there has been a failure in the development of the costo vertebral muscles a much wider hiatus results (see Fig 273 (2) and (3)) This type is found most commonly on the left side There may be a peritoneal sac but more often a free communication exists between the peritoneal and pleural cavities through which stomach small bowel and colon may prolapse Less common sites for congenital herniæ are the retrosternal space of Morgagni (or Larrey) and the left and right cupolas of the diaphragm

Pre-operative Considerations.—In most cases the general health has suffered through long-standing dyspepsia bouts of vomiting hæmorrhages and the effects of chronic pulmonary embarrassment

It is advisable except of course in the event of strangulation to postpone operative treatment until the appropriate measures have been taken to improve the patient's condition. Congenital shortness of the œsophagus should be considered in a case of para-œsophageal hernia before deciding upon its treatment for it precludes successful repair of the hernia.

General Operative Principles.—Endotracheal anæsthesia is most essential. Access to the diaphragm may be gained via the abdomen, the chest, or a combination of these routes.

The *abdominal approach* gives adequate exposure if the hernial protrusion is small and likely to be contained in a sac. A left para median incision is made and the left lobe of liver retracted to the right after section of its triangular ligament.

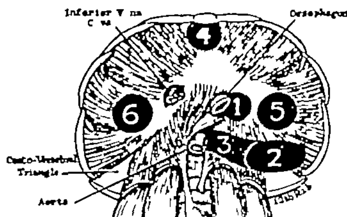


FIG. 273

Sites of the various diaphragmatic herniæ in order of frequency

The *transpleural approach* gives much the better exposure and is to be preferred in the pleuro-peritoneal tubes. The pleural cavity is opened by an incision in the seventh interspace the eigth rib divided in front and behind and the rib-spreader inserted.

The phrenic nerve need only be crushed where the gap to be closed is a wide one. This is done as it crosses the pericardium.

If the sac of say a para-œsophageal hernia is easily accessible the next step is to incise the pleural covering and at the same time define the terminal part of the œsophagus. If obscured by adhesions it is safer to approach the hiatus by first incising the diaphragm about an inch away. The more massive herniæ such as are found in the left dorsal region require careful dissection before the displaced viscera which usually adherent are freed. In this type an abdominal exposure may be necessary in addition in order that the viscera can be held in position while the repair is being carried out from above.

The suture material used depends on the width of the gap. Catgut or silk are adequate for the para-œsophageal type. For the pleuro-peritoneal group a fascial repair is usually performed. If difficulty is encountered, in approximating the anterior edge to the posterior it is an advantage to encircle the adjacent rib with the fascial strip.

Finally any raw areas in the mediastinal pleura are dealt with and the parietal wound closed Catgut sutures encircling the seventh and eighth ribs are used and as the last is about to be tied the anæsthetist raises the intra pulmonary pressure During convalescence a pleural effusion commonly develops and may need to be aspirated

OBTURATOR HERNIA

An obturator hernia is generally discovered when the abdomen is being explored for intestinal obstruction of obscure origin In such cases the surgeon should resist the temptation to reduce the hernia by blind traction upon the obstructed loop of intestine because this involves the risk of tearing the bowel and moreover leads to spilling of toxic exudate from the sac into the abdominal cavity Instead he should expose the hernia in the thigh and relieve the obstruction under direct vision.

An incision is made over the femoral (Scarpa s) triangle The adductor longus muscle is displaced medially and the pectineus retracted or partly divided The sac is then exposed as it projects either above or between the fibres of the obturator externus and is opened At this stage it may be possible to free the intestine and reduce it if it is necessary to enlarge the opening the obturator membrane should be incised downwards

POST-OPERATIVE CARE

The patient need not lie completely supine and inert after a herniorrhaphy for in so doing the general muscle tone suffers and the venous stagnation that ensues particularly in elderly patients may invite a troublesome thrombosis Indeed, there is a growing tendency to allow patients up on the day following operation It is claimed that early ambulation maintains the local muscle tone at a time when the tensile strength of the catgut is at its best and minimises the risk of chest and venous complications This is a complete reversal of the policy from that which insisted on a stay of two or three weeks in bed for all cases Each case must be judged on its own merits but it is probably safe to let young adults with inguinal hernias and all femoral hernias out of bed soon after operation but adhere to the old fashioned methods in the case of repairs carried out for direct inguinal, umbilical and ventral hernias

The following scheme has been drawn up by the Army Medical Department Bulletin Supplement No 4 1943 in order to shorten the period of rehabilitation and hasten the soldier s return to military duties after inguinal operations It is equally suitable for civilian patients Each of the exercises may be repeated six times to begin with and the whole group performed four times a day

(1) *Lying on the back* —Draw the knees up sliding the foot along the bed As a progression of this exercise the foot can be lifted off the bed for a moment when the knees are fully bent Further progression should be made by lifting the feet from the bed with the knees

less bent until finally it becomes a straight leg raising to vertical This should take from three to four weeks the time depending entirely on the individual strength of the patient (Rectus abdominis)

(2) *Lying on back knees fully bent grasping sides of bed* —Roll the knees to left and right as far as they will go without discomfort keeping the shoulders flat on the bed. Progressed by lifting the feet off the bed before starting the exercise Further progression made by performing the exercise with the legs straighter until finally they are quite straight (Internal and external oblique)

(3) *Lying on the back* —Deep inhalation followed by full exhalation. When the lungs are empty contract the abdominal wall and pull it in as far as possible A few normal breaths should be taken between each repetition (Transversalis)

After operation for a small hernia sedentary workers may resume employment after a further two or three weeks convalescence but must be warned to avoid for several months any actions that will strain the wound such as lifting heavy weights or reaching for objects on high shelves Longer convalescence is required after operation for the larger types of hernia Labourers should generally be kept off heavy work for three to six months Trusses of any kind are undesirable after the ordinary operations for inguinal hernia but umbilical repairs should be supported subsequently by a well fitting body belt or corset

Sepsis is a not infrequent complication of inguinal wounds but if every precaution is taken with skin toilet and non absorbable suture material of doubtful sterility such as floss silk is avoided its incidence will be much reduced

Pain in hernial scars may follow trauma to the ilio inguinal nerve or constriction of the cord at the internal or external rings but malingering must be excluded

H W

REFERENCES

Abel, A. L., and Hunt A. H. (1948). "Stainless Steel Wire for Closing Abdominal Incisions and for Repair of Hernia. *Brit med. J* Aug. 21 370

Anson B. J., and McVay C. B (1937). "The Anatomy of the Inguinal and Hypogastric Regions of the Abdominal Wall." *Anat. Rec* 70 211

Brandon W J M. (1945) Inguinal Hernia. *Lancet* 1, 167

Edwards H. (1943). "Inguinal Hernia. *Brit J Surg* 31, 172.

Gallie, W E. and Le Mesurier, A. B (1924). "The Transplantation of the Fibrous Tissues in the Repair of Anatomical Defects. *Brit J Surg.*, 12, 289

Mair, G B. (1945). The Use of Whole Skin Grafts as a Substitute for Fascial Sutures in the Treatment of Herniae *Brit. J Surg.*, 32, 381

Ogilvie, W H. (1937). "Discussion on Hernia. *Proc Roy Soc. Med.*, 30, 529

Olsen A. M. and Harrington S. H. (1948). "Oesophageal Hiatus Hernia. *J thorac Surg.*, 17 180

CHAPTER XXXII

AFFECTIONS OF THE STOMACH AND DUODENUM

CONGENITAL PYLORIC STENOSIS

THIS disease which affects young infants especially males is characterised by pyloric obstruction associated with hypertrophy of the pyloric canal.

The hypertrophy affects the circular muscle and gives rise to a bobbin like swelling which in some cases is palpable The hypertrophy extends to the pylorus but never involves the duodenum, while proximally it gradually diminishes as the incisura is approached

This condition is now recognised as an inherited abnormality of recessive type It is generally believed to arise as a result of neuro-

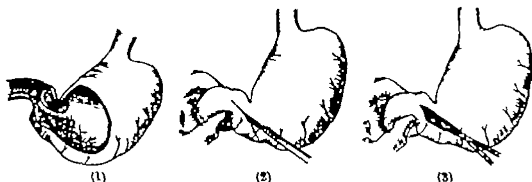


FIG 274

Congenital hypertrophic pyloric stenosis. (1) Autopsy specimen cut to show hypertrophy of circular muscle of pyloric canal. (2) Rammstedt operation the incision. (3) Muscle fibres separated, showing mucous membrane intact

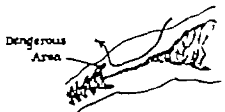
muscular inco-ordination with compensatory hypertrophy of the muscle of the pyloric canal

The outstanding feature is vomiting In the early stages this *is no* more than regurgitation of a fraction of the feed and this must be distinguished from the common regurgitation due to improper *feeding* For this reason in early cases before the diagnosis is established the treatment should be on conservative lines

The diet must first be regulated and small feeds should be given frequently of a breast milk substitute of known reliability Anti spasmodics may be given orally twenty minutes before each feed. Eumydrin (atropin methyl nitrate) is in wide use the dose being 1 to 5 c c of 1 10 000 solution or atropin *itself* in doses working up from 3 minims of 1 1 000 solution until the atropin flush appears Improvement is often dramatic

In severe cases and when milder cases fail to respond to conservative measures immediate operation is advised Promptitude in coming to a decision is essential for infants are intolerant of dehydration and delay adds greatly to the operative risk. In the later stages even in skilled hands the mortality may be over 10 per cent

The operation now in regular use is the procedure described by Rammstedt in 1912, which consists in dividing the hypertrophied circular muscle of the pyloric canal Feeds should be continued until two hours before operation If the infant is dehydrated glucose saline solution may be injected subcutaneously or beneath the pectoral muscles If malnutrition is severe a *blood transfusion may be given* (10 c c per lb body weight) or infusion of casein hydrolysate



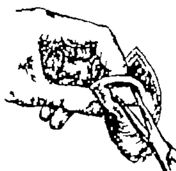


Fig 275

Congenital hypertrophic pyloric stenosis. Above diagram illustrating the hypertrophied muscle and the dangerous area where the lumen is liable to be opened at the point of transition to the thin duodenal wall. Below: method of ensuring complete division of muscle without damage to mucosa.

For the operation the infant is swathed in wool and bandaged on a wooden cross so padded as to render the epigastrium prominent Heat *should be applied by hot bottles* For anæsthesia open ether is satisfactory if the infant is in good condition, otherwise a local anæsthetic may be used

A 2 in right rectus incision is used. It should be placed immediately below the rib margin so that the liver will subsequently protect it and prevent wound dehiscence a common complication formerly in undernourished infants The pylorus which in the young infant is very mobile is hooked out of the wound and steadied with a finger and thumb Its anterior wall is then incised longitudinally at a site free from blood vessels the incision being about 1 in in length. The wound is deepened through *the muscle coat and great care is* necessary to ensure that the mucosa is not divided especially in the dangerous area where the hypertrophied muscle of the pyloric canal gives way to the thin duodenal wall The sides of the wound may be separated gently by means of a hæmostat to ensure that all muscle bundles are divided Any bleeding points may be ligated but no sutures are required and when the muscle division has been completed *the pylorus is returned to* the abdomen without further treatment The abdominal wall is then closed in the usual manner

In the post-operative phase it is important to avoid gastro-enteritis which is the common complication Feeds may be begun six hours after the operation At first the feeds should be given *half hourly* and should consist of glucose in saline solution Later increasing amounts of milk and water are given

PEPTIC ULCER

The relative merits of medical and surgical treatment and the choice of operation for peptic ulcer have formed the subject of much discussion during the past sixty years and there is still no complete agreement. Initially and for a long time gastrojejunostomy held the field and indeed it still has a recognised place especially for the type of case for which it was designed, that is to say to act as a short-circuiting procedure to relieve the mechanical obstruction of pyloric stenosis. For other types of ulcer it is generally considered less suitable though it still retains its staunch advocates.

Partial gastrectomy is the operation most widely performed at the present time though it carries a higher mortality than gastrojejunostomy and is by no means free from complications. Its main advantage lies in the fact that removal of a large part of the acid secreting portion of the stomach almost eliminates the risk that a new ulcer will develop at the anastomosis.

In recent years vagotomy has come into wide use for duodenal (though not for gastric) ulcer and for jejunal ulcer. The vagus nerve is the motor and secretory nerve to the stomach and vagotomy has effects related to both these functions. Spasm of the gastric musculature is relieved with benefit to the ulcer but in some cases the motor atony is severe and acute gastric retention develops requiring a short-circuiting operation for its relief. The gastric secretion is also reduced, especially the night secretion which is diminished in both volume and acidity. The hormonal secretion of acid is of course unaffected.

Opinion as to the value of vagotomy is acutely divided. Its immediate results are often quite dramatic particularly in cases of jejunal ulcer but there is some doubt as to the permanency of the benefit.

Choice of Operation.—In *gastric ulcer* there is general agreement that partial gastrectomy is the operation of choice and indeed is as a rule the only possible method of treatment though a few surgeons substitute gastrojejunostomy in bad risk cases especially for an ulcer associated with pyloric spasm or stenosis.

In *duodenal ulcer* the field of choice is wider and gastrectomy, gastrojejunostomy and vagotomy all have their advocates. Partial gastrectomy is probably the most effective method in use at the present time for duodenal ulcer in young men. Gastrojejunostomy is to be preferred in women and in elderly people of either sex in whom the acid level is usually low and the risk of anastomotic ulcer consequently slight. It should be practised also by the conservative surgeon particularly if lacking in experience in any cases in which resection would be dangerous on account of technical difficulties.

Vagotomy as has been indicated is still in the experimental stage but the tendency now is to regard it as an ancillary measure—a supplement to gastrojejunostomy—rather than sufficient in itself. If performed without an anastomosis it should be restricted to cases

to preference According to the usual technique two sutures are used (generally size 2/0 chromic catgut and mounted on fine needles) the one as a seromuscular suture uniting the outer coats of stomach and jejunum the second as a hæmostatic suture through and through all coats The seromuscular suture by a single row of stitches coapts the surfaces of jejunum and stomach over a length of about 3 in (Fig 277 (1)) and is then tied and set aside without being cut Incisions about 2½ in long are then made in both viscera that in the thicker walled viscus (the stomach) being slightly longer than in the jejunum Special care must be taken that no " bridge of mucous membrane is left

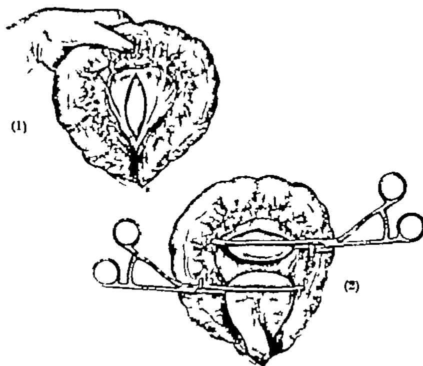


Fig 276

Posterior gastrojejunostomy

(1) Transverse colon held upwards, mesocolon incised, posterior wall of stomach exposed ( ) Stomach and jejunum held in clamps.

which might obstruct the stoma The exposed portions of the two viscera are now cleaned out with pledgets of gauze all contents being removed The hæmostatic suture is now inserted through and through all coats with close stitching to control the divided vessels When the end of the row is reached the suture is knotted on itself to prevent purse-string narrowing when subsequently drawn tight and is then continued in front of the stoma To invert the mucous edges and bring serous surfaces in contact the suture is now introduced as a post-mortem stitch —like a bootlace from within outwards on either side—or as a loop on the mucosa stitch (Fig 277 (3)) When this suture has been completed the seromuscular suture is then resumed in front of the stoma so as to bury the hæmostatic row and coapt serous coat to serous coat

The anastomosis is now complete At this stage (if not already

lone) the edge of the opening in the mesocolon is tacked to the tomach by several interrupted stitches, thus fixing the anastomosis below the mesocolon and ensuring that no loop of small intestine may herniate alongside the anastomosis into the lesser sac

Finally the transverse colon is restored to its natural position the le of the anastomosis is inspected the jejunum arranged neatly in position and the wound closed

Complications —Bleeding from the suture line may occur during the few hours immediately following operation Usually it is moderate in degree and consists of a few ounces of brownish fluid vomited or aspirated into the suction bottle but if the hæmostatic suture has been applied with insufficient tension the bleeding may be considerable In such circumstances gentle lavage of the stomach should be performed with warm water containing adrenaline solution (1 c c of 1 1000 solution) while the customary treatment for hæmorrhage should be instituted including a slow drip transfusion In rare cases if the bleeding continues actively it will be necessary to reopen the abdomen expose the anastomosis and control the bleeding vessel

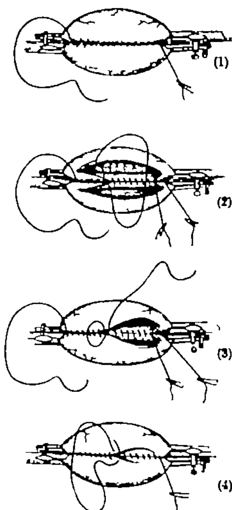


FIG 277

Lateral anastomosis.

(1) First seromuscular suture completed (2) Hæmostatic suture being applied. (3) Hæmostatic suture now being inserted to infold the tissues in front of the stoma. (4) Final layer—the anterior seromuscular suture.

Bilious vomiting — the so-called vicious cycle vomiting — is a troublesome and sometimes persistent but usually not serious complication It is generally due to some technical error in the performance of the anastomosis which has led to distortion of the jejunal loop and partial intestinal obstruction Occasionally it is due to kinking of the jejunum by adhesions or to herniation of small intestine round the anastomosis or through the mesocolic opening Whatever the cause of the obstruction its effects are exaggerated by secondary dilatation of the stomach and if this factor is eliminated the obstruction will in most cases, rectify itself The initial treatment therefore is to empty the stomach and keep it empty by means of a nasal tube connected to a constant suction apparatus Generally it is necessary to rectify the fluid balance by intravenous administration of salt solution If under such treatment the bilious regurgitation persists it is necessary to reopen the abdomen and deal with the cause of obstruction In most

to preference According to the usual technique two sutures are used (generally size 2/0 chromic catgut and mounted on fine needles) the one as a seromuscular suture uniting the outer coats of stomach and jejunum the second as a hæmostatic suture through and through all coats The seromuscular suture by a single row of stitches coapts the surfaces of jejunum and stomach over a length of about 3 in (Fig 277 (1)) and is then tied and set aside without being cut Incisions about 2½ in long are then made in both viscera that in the thicker walled viscus (the stomach) being slightly longer than in the jejunum Special care must be taken that no bridge of mucous membrane is left

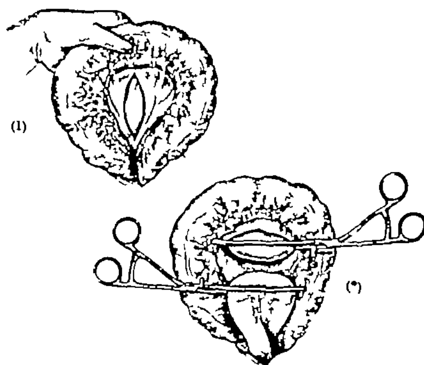


Fig 276
Posterior gastrojejunostomy
(1) Transverse colon held upwards, mesocolon incised, posterior wall of stomach exposed. (2) Stomach and jejunum held in clamps.

which might obstruct the stoma The exposed portions of the two viscera are now cleaned out with pledgets of gauze all contents being removed The hæmostatic suture is now inserted 'through and through all coats with close stitching to control the divided vessels When the end of the row is reached the suture is knotted on itself to prevent purse-string narrowing when subsequently drawn tight and is then continued in front of the stoma To invert the mucous edges and bring serous surfaces in contact the suture is now introduced as a post-mortem stitch —like a bootlace from within outwards on either side—or as a loop on the mucosa stitch (Fig 277 (3)) When this suture has been completed the seromuscular suture is then resumed in front of the stoma so as to bury the hæmostatic row and coapt serous coat to serous coat

The anastomosis is now complete At this stage (if not already

done) the edge of the opening in the mesocolon is tacked to the stomach by several interrupted stitches, thus fixing the anastomosis below the mesocolon and ensuring that no loop of small intestine may herniate alongside the anastomosis into the lesser sac

Finally the transverse colon is restored to its natural position the lie of the anastomosis is inspected the jejunum arranged neatly in position and the wound closed

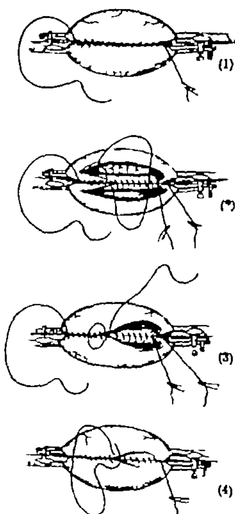


Fig 277

Lateral anastomosis.

(1) First seromuscular suture completed (2) Hæmostatic suture being applied. (3) Hæmostatic suture now being inserted to infold the tissues in front of the stoma. (4) Final layer—the anterior seromuscular suture

Complications —Bleeding from the suture line may occur during the few hours immediately following operation Usually it is moderate in degree and consists of a few ounces of brownish fluid vomited or aspirated into the suction bottle but if the hæmostatic suture has been applied with insufficient tension the bleeding may be considerable In such circumstances gentle lavage of the stomach should be performed with warm water containing adrenaline solution (1 c c of 1 1000 solution) while the customary treatment for hæmorrhage should be instituted, including a slow drip transfusion In rare cases if the bleeding continues actively it will be necessary to reopen the abdomen expose the anastomosis and control the bleeding vessel

Bilious vomiting—the so-called vicious cycle vomiting—is a troublesome and sometimes persistent but usually not serious complication It is generally due to some technical error in the performance of the anastomosis which has led to distortion of the jejunal loop and partial intestinal obstruction Occasionally it is due to kinking of the jejunum by adhesions or to herniation of small intestine round the anastomosis or through the mesocolic opening Whatever the cause of the obstruction its effects are exaggerated by secondary dilatation of the stomach, and if this factor is eliminated the obstruction will in most cases rectify itself The initial treatment therefore is to empty the stomach and keep it empty by means of a nasal tube connected to a constant suction apparatus Generally it is necessary to rectify the fluid balance by intravenous administration of salt solution If under such treatment the bilious regurgitation persists it is necessary to reopen the abdomen and deal with the cause of obstruction. In most

cases this is most effectively achieved by performing a small side to-side anastomosis between the afferent and efferent loops of jejunum

The most common complication of gastrojejunostomy is the development of an ulcer in relation to the anastomosis This is con sidered on p 580

Partial Gastrectomy

Methods —The original Billroth operation consisted of resection of the pyloric segment with end to-end anastomosis of stomach and duodenum In its original form it is now rarely used Schoemaker s modification however after a period of partial eclipse is now coming into favour again In this operation the lesser curve and adjacent parts of the anterior and posterior walls of the stomach are removed along with the pyloric segment The greater part of the cut surface is closed to make a new lesser curve while the lower part of the open end of the stomach is anastomosed end to-end to the duodenum Schoemaker s operation is indicated particularly for gastric ulcer and should rarely be used for duodenal ulcer owing to the technical difficulty of mobilising the duodenum

Most surgeons at the present time employ the Polya operation or one of its modifications in which after removal of a large part of the stomach the duodenal stump is closed while the proximal cut end of the stomach is united, end to-side to the jejunum The jejunum may be brought up to the stomach through an opening in the mesocolon (retrocolic) or in front (antecolic) and is usually arranged so that the proximal part of the jejunum some 5 or 6 in from the duodenojejunal flexure is opposed to the lesser curvature of the stomach In the original Polya operation the whole width of the cut stomach is joined to the jejunum with an anastomosis some 2½ to 3 in in length In Finsterer s modification only the lower half of the cut edge of the stomach is used for the anastomosis the upper half being inverted and closed In Hofmeister s modification an attempt is made to fashion a valve mechanism at the anastomosis to prevent reflux of gastric contents into the afferent loop

Whichever method is adopted, it is now well recognised that in cases with high gastric acidity—that is to say in most cases of duodenal ulcer—the resection should be made at a high level in order to remove the greater part of the acid-secreting stomach wall This usually involves resection of approximately five-sixths of the whole stomach

It is also established that when possible the pylorus and the first inch of the duodenum should be removed, in order to reduce to the minimum the production of gastrin the main hormone concerned in the chemical mechanism of gastric secretion If owing to fixation of the ulcer or inflammatory adhesions around it removal of the first part of duodenum would prove too formidable the stomach may be divided proximal to the pylorus and the stump enfolded—resection with exclusion It is generally advisable to remove the pylorus at a second session a few weeks later by which time the inflammatory fixation will have resolved If this is not done it is believed that owing to continued production of the hormone *gastrin* the acid

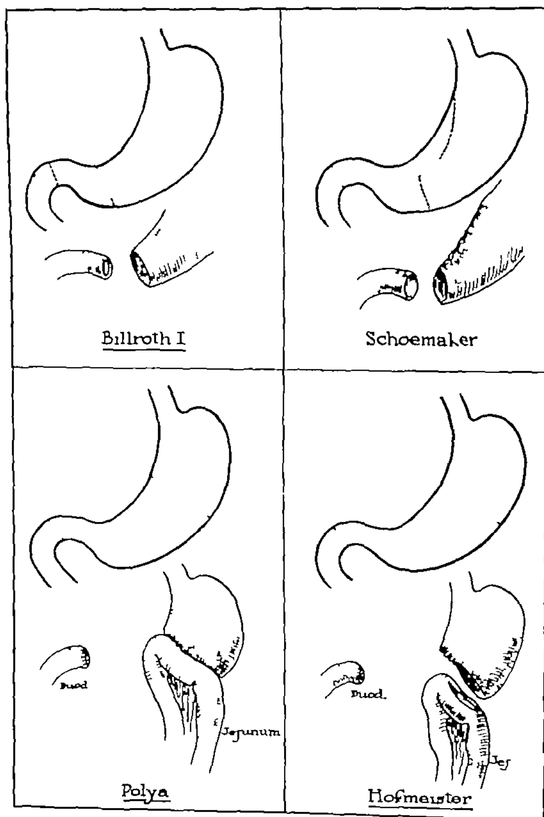


Fig. 278
Types of Gastrectomy

cases this is most effectively achieved by performing a small side-to-side anastomosis between the afferent and efferent loops of jejunum

The most common complication of gastrojejunostomy is the development of an ulcer in relation to the anastomosis This is con sidered on p 580

Partial Gastrectomy

Methods—The original Billroth operation consisted of resection of the pyloric segment with end to-end anastomosis of stomach and duodenum In its original form it is now rarely used Schoemaker s modification however after a period of partial eclipse is now coming into favour again In this operation the lesser curve and adjacent parts of the anterior and posterior walls of the stomach are removed along with the pyloric segment The greater part of the cut surface is closed to make a new lesser curve while the lower part of the open end of the stomach is anastomosed end to-end to the duodenum. Schoemaker s operation is indicated particularly for gastric ulcer and should rarely be used for duodenal ulcer owing to the technical difficulty of mobilising the duodenum

Most surgeons at the present time employ the Polya operation or one of its modifications in which after removal of a large part of the stomach the duodenal stump is closed while the proximal cut end of the stomach is united end to-side to the jejunum The jejunum may be brought up to the stomach through an opening in the mesocolon (retrocolic) or in front (antecolic) and is usually arranged so that the proximal part of the jejunum some 5 or 6 in from the duodenojejunal flexure is opposed to the lesser curvature of the stomach In the original Polya operation the whole width of the cut stomach is joined to the jejunum with an anastomosis some $2\frac{1}{2}$ to 3 in in length In Finsterer s modification only the lower half of the cut edge of the stomach is used for the anastomosis the upper half being inverted and closed. In Hofmeister s modification an attempt is made to fashion a valve mechanism at the anastomosis to prevent reflux of gastric contents into the afferent loop

Whichever method is adopted it is now well recognised that in cases with high gastric acidity—that is to say in most cases of duodenal ulcer—the resection should be made at a high level in order to remove the greater part of the acid-secreting stomach wall This usually involves resection of approximately five-sixths of the whole stomach

It is also established that when possible the pylorus and the first inch of the duodenum should be removed, in order to reduce to the minimum the production of gastrin the main hormone concerned in the chemical mechanism of gastric secretion If owing to fixation of the ulcer or inflammatory adhesions around it removal of the first part of duodenum would prove too formidable the stomach may be divided proximal to the pylorus and the stump enfolded—resection with exclusion. It is generally advisable to remove the pylorus at a second session a few weeks later by which time the inflammatory fixation will have resolved. If this is not done it is believed that owing to continued production of the hormone *gastrin* the acid

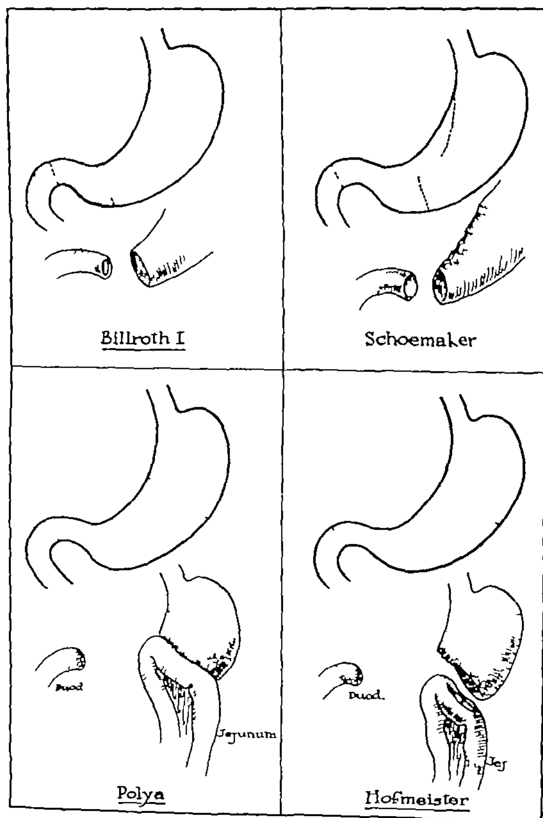


FIG. 278
Types of Gastrectomy

secretion will persist and anastomotic ulcer will be likely to develop Alternatively some surgeons recommend that at the original operation the mucous membrane of the pyloric segment should be cored out and removed.

Technique of Gastrectomy—The following account describes a modified Polya gastrectomy of the type commonly practised It should be noted however that many surgeons make minor changes in the technique and introduce individual modifications too numerous to detail.

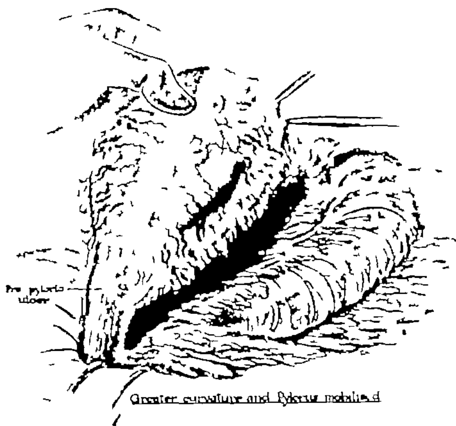


Fig 279
Gastrectomy Freeing the greater curvature.

1 Exposure is gained most satisfactorily by a high left paramedian incision

2 The greater curvature of the stomach is detached from the colon by division of the gastrocolic omentum. Small branches of the gastro-epiploic vessels must be divided at this stage but care must be taken not to divide the middle colic artery which with the mesocolon is often adherent to the gastrocolic omentum Towards the right side the hepatic flexure of the colon is stripped down off the pancreas and duodenum

3 The pylorus and first part of duodenum are mobilised Above the right gastric artery is divided as it approaches the stomach. Below either the gastroduodenal or its gastro-epiploic branch and the superior pancreatico-duodenal artery are divided along with numerous small



FIG. 280

Gastrectomy Pylorus freed and clamped. Insets show routine method of closure



FIG. 281

Gastrectomy Stomach drawn upwards and rotated. Left gastric artery exposed.

branches entering the duodenal wall This stage may be difficult in the presence of a duodenal ulcer It is simplified if as a preliminary step the second part of the duodenum *is mobilised to provide* a starting point from which to work upwards towards the pylorus

4 The duodenum is divided and the stump *invaginated.* *Many* methods have been described for dealing with the duodenal stump According to the usual method the duodenum *is divided between two*

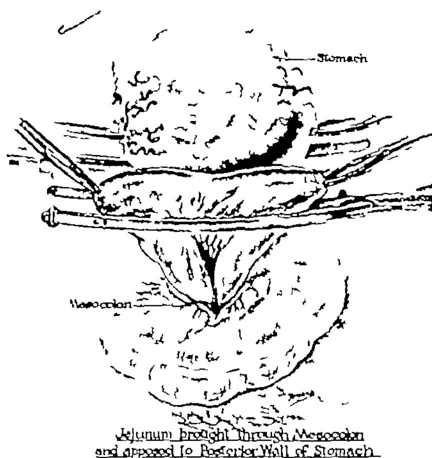


Fig 28.

Gastrectomy Stomach rotated upwards, exposing posterior wall. Jejunum brought up through mesocolon (*stomach greatly foreshortened*).

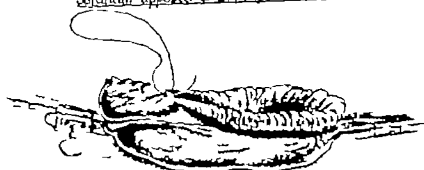
narrow bladed clamps a continuous stitch is applied to the stump and *pulled tight as the clamp is removed* and lastly one or two further rows of sutures are applied to ensure that the stump is well invaginated and *sealed off*

If the duodenum is too short or too fixed the clamp may be omitted the duodenum *is cut across* and the open end closed and enfolded by successive rows of sutures

5 *The lesser curvature is freed* by dividing the lesser omentum As the stomach is turned over to the left and drawn upwards the left



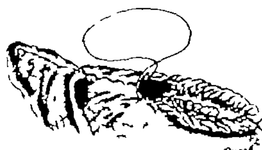
Jejunum apposed to Cut edge of Stomach



Closure of Upper Third of Cut edge of Stomach



Posterior through and through suture



Anterior inverting suture

FIG. 283

Gastrectomy Modified Hofmeister anastomosis (a) Stomach divided and removed, jejunum unopened; (b) closure of upper third of cut edge of stomach (c) jejunum opened and anastomosed to lower two-thirds of stomach (d) anastomosis being completed (seromuscular suture not shown).

gastric vessels are put on the stretch and readily displayed The artery is divided proximal to its œsophageal branch which is also ligated

6 The stage is now set for division of the stomach and anastomosis of its cut end to the jejunum This may be done with or without clamps The line of division is from just below the cardia to the greater curvature above the lowest of the vasa brevia If the Hofmeister technique is followed the upper half of the divided stomach is now closed by a continuous stitch

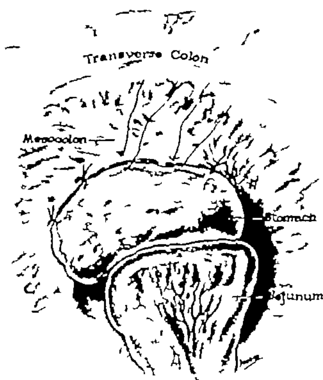


FIG. 284

Gastrectomy Final stage. Anastomosis drawn down through mesocolon.

The first part of jejunum is now identified brought behind or in front of the colon and placed in relation to the stomach so that it runs from lesser to greater curvature The site for anastomosis is usually some 6 or 8 in from the duodenojejunal flexure The anastomosis is completed according to the usual technique

Complications of Gastrectomy—Chief among the immediate complications of gastrectomy is *leakage from the duodenal stump* Owing to its thin wall and lack of a serous coat it is not easy to close securely particularly when fixed by inflammatory adhesions and any fault in technique may have dangerous consequences Another factor predisposing to leakage is the development (owing to œdema or kinking of the jejunum) of a partial obstruction at the anastomosis with

consequent distension of the duodenum This can be prevented if at the conclusion of the operation an indwelling gastric tube is guided through the anastomosis into the afferent jejunal loop and left there for twenty four hours with continuous suction

Leakage from the stump gives rise to peritonitis which rapidly becomes generalised The treatment when leakage is suspected is to open the abdomen and if possible close the leak a difficult procedure at this stage owing to friability of the tissues A drainage tube should be inserted to the region of the stump and continuous suction applied to prevent digestion of the wound by the duodenal secretion The severe toxæmia and dehydration must be combatted by copious intravenous infusions In favourable cases after a stormy course the peritonitis will subside and any fistula will eventually close spontaneously

Among the later complications of gastrectomy the most important are the so-called dumping syndrome and the hypoglycæmic syndrome which will be described immediately Anastomotic ulcer is of rare occurrence after the modern high gastrectomy Hypochromic anæmia may occur especially in women but can be cured by administration of iron in adequate doses Loss of weight—or failure to regain weight—is not infrequent and should be treated by a high protein dietary Riboflavine deficiency may occur and should be prevented by appropriate medication.

The *dumping syndrome* is characterised by epigastric distension with nausea weakness and collapse It occurs immediately after a meal especially the main meal of the day lasts for an hour and is then terminated by bilious vomiting This syndrome appears to be due to a partial obstruction of the proximal jejunal loop aggravated by a large meal. It usually develops a few weeks after operation and in most cases it tends to improve in the course of a few months

The *hypoglycæmic syndrome* is different in ætiology though somewhat similar in clinical course When a meal of sugar or carbohydrate is taken owing to the rapid passage of food into the absorptive area of the small intestine the sugar is absorbed rapidly and the blood sugar rises to a high level This hyperglycæmia is of common occurrence after gastrectomy and indeed also after gastrojejunostomy and is usually symptomless In occasional cases however the great rise in the blood sugar is followed by a rebound to a subnormal level and in this hypoglycæmic phase symptoms may occur in all respects identical with the symptoms of spontaneous or insulin induced hypoglycæmia and like them readily curable by administering sugar

Technique of Vagotomy—In the lower part of the thorax the vagus trunks form a plexus which is distributed over and around the œsophagus As it is traced down towards the diaphragm the plexus is seen to resolve itself into two main bundles, one anterior and the other posterior Immediately below the diaphragm the anterior bundle gives off a hepato-pyloric branch which passes between the layers of the lesser omentum towards the portal fissure The vagus bundles then break up into numerous branches which are distributed to the anterior and posterior walls of the stomach

Vagotomy may be performed by *the thoracic or the abdominal* route The thoracic approach has been favoured on the grounds that it enables all nerve fibres to be divided with greater certainty and is unlikely to be followed by regeneration The abdominal approach on the other hand enables one to view the pathology to assess the risk of pyloric obstruction and if necessary *to perform a gastro-jejunostomy* (see p 509) At the present time most surgeons who practice vagotomy prefer the abdominal route

The abdomen is opened through a high left paramedian incision The left lobe of the liver is mobilised by dividing the coronary ligament which binds it to the diaphragm The lower end of the *œsophagus is* exposed isolated and retracted downwards by an encircling piece of tape Careful dissection is then carried out to define and divide all vagus fibres at the level of the hiatus

The *Insulin Test Meal* should be carried out before vagotomy and again some weeks later in order to confirm that the resection has been complete This test is based upon the observation that the rise in gastric secretion brought about when hypoglycæmia is induced is due to stimuli transmitted via the vagus nerves and is abolished only when all fibres of those nerves have been divided.

A dose of insulin is given sufficient to reduce the blood sugar to 50 mg per cent (15 units usually suffices) and samples of gastric juice are withdrawn as for the ordinary fractional test meal The resulting hypersecretion becomes evident within thirty to forty minutes

The *preparation* for vagotomy and the *post-operative care* are much the same as for gastrectomy Owing to the risk of gastric dilatation the nasal tube should be left in place and constant suction maintained for two or three days In some cases it is necessary to reopen the abdomen and perform gastrojejunostomy

Gastrojejunal Ulcer

The surgical treatment of gastrojejunal ulcer is demanded where the symptoms persist or recur in severe form despite medical care

Formerly several methods were practised, including local resection of the ulcer resection with plastic repair of the stoma resection of ulcer and anastomosis with restoration to the original state or perform ance of a new gastrojejunostomy All these methods however are now obsolete and for practical purposes only two operations require consideration at the present time namely partial gastrectomy (with removal *of the loop of jejunum involved in anastomosis) and vagotomy* The former procedure presents certain technical difficulties and except in skilled hands carries a considerable mortality Apart from the operative risk however the results are highly satisfactory and complete relief of symptoms may be expected in a large proportion of cases *Vagotomy (which* in cases of this type is best performed by the thoracic route) has the advantage of being technically much easier to perform, and is less dangerous Its immediate results appear to be good, but at the present time its final value cannot be assessed

Technique of Gastrectomy with Resection of Jejunum

Where the original operation has been a posterior gastrojejunostomy resection is rendered difficult by inflammatory fixation of the ulcer to the transverse mesocolon The first step before proceeding to resection is to separate the anastomosis from the mesocolon At this stage great care must be taken to avoid damage to the middle colic artery upon which depends the blood supply to the middle portion of the transverse colon If this artery is damaged the colon must be watched carefully and if at the conclusion of the operation it appears non viable it should either be resected or brought out of the wound as a Paul Mikulicz colostomy

The next step is to resect the portion of jejunum bearing the ulcer In most cases this implies resection of a segment 4 or 5 in long with end to-end anastomosis Special difficulty is encountered in cases where the original gastrojejunostomy is of the no-loop or short loop variety If so the duodenojejunal flexure should be mobilised by dividing the peritoneal reflection and the ligament of Treitz and freeing the third part of the duodenum as it lies behind the mesenteric vessels By this manœuvre it is possible to free the jejunum sufficiently to allow the resection and anastomosis to be performed without difficulty

The remainder of the operation follows the lines of a simple gastrectomy

Gastrojejuno-Colic Fistula

This condition results from perforation of a gastrojejunal ulcer into the transverse colon The main clinical feature is diarrhœa which may be severe and lead to profound dehydration and emaciation Formerly the diarrhœa was attributed to the irritating effect of gastric juice on the colon but it is now recognised to be due to enteritis set up by the reflux of colon contents through the fistula into the jejunum In some cases colon contents reach the stomach and give rise to belching of flatus and fæcal vomiting

The clinical features vary in degree and may abate for long periods but in general they are of severe character Consequently the patient is usually in a poor state of nutrition deficient in proteins (even to the extent of being œdematous) and grossly dehydrated In these circum stances the pre-operative preparation must be thorough Salt solutions should be given intravenously in adequate amount and protein hydroly sate may be used with advantage while plasma or whole blood trans fusions may need to be repeated The possibility of deficiencies in vitamin B and vitamin C must be borne in mind While this therapy is in progress, the bowel should be washed out repeatedly while succinol sulphathiazole should be given by the mouth to reduce the intestinal infection

The operative technique must be planned with due regard to the patient s condition In exceptional cases it is possible to cut across the fistula close the opening into the colon by a purse string stitch and proceed to treat as for gastrojejunal ulcer Wilkie s operation is

a less severe tax on the patient The colon is divided at two points, a few inches proximal and distal to the fistula The central ends are turned in and buried by purse-string sutures so that the middle part of the transverse colon forms a closed sac drained by the fistula The continuity of the colon is restored by anastomosis between the two lateral ends This operation at once relieves the symptoms due to the fistula The median segment of colon may be removed later though this is not always necessary

In a bad risk case either of the above methods involves too much risk. In such circumstances the most satisfactory measure is to perform colostomy proximal to the fistula By preventing reflux of colon contents this procedure relieves the enteritis Later when the general condition is improved one of the methods described above may be carried out

Perforated Peptic Ulcer

Few emergencies demand more urgent treatment than perforation of a peptic ulcer for in this disease the mortality is directly proportional to the time required to institute operation If the perforation be closed within four hours the mortality is of the order of 5 per cent or less in another few hours it rises to 10 per cent or more while if the delay is over twelve hours it may reach 50 per cent Early diagnosis and prompt treatment are therefore of vital importance

Fortunately the operative technique is of the simplest In the great majority of cases it suffices to obliterate the perforation with a few stitches and to close the wound. If much exudate is present it should be evacuated by suction tube or by means of swabs Drainage of the peritoneal cavity is unnecessary—and may be harmful—in early cases and its value even in advanced cases is open to argument

The question of whether to perform gastroenterostomy—or even gastrectomy—at the time of a perforation has been debated for many years It is generally agreed that if there is incipient stenosis the narrowing may be aggravated as a result of perforation and in perhaps 5 per cent of cases treated by simple closure it is necessary to reopen the abdomen within a few weeks on account of gastric retention When therefore during the operation for closure of the perforation the pylorus is found to be narrowed or the stomach dilated as a result of retention if the patient s general condition permits a gastro-jejunostomy should be performed.

In gastric perforations owing to the possibility of mistaking a malignant ulcer for a simple one it is often wise to perform immediate gastrectomy provided the circumstances are favourable In duodenal perforations on the other hand it is doubtful if a good case can be made out for such treatment for it is now established that further treatment is by no means always necessary While the belief that perforation cures the ulcer is demonstrably false about 30 per cent of patients remain symptom free for several years after a perforation while a further 30 per cent have symptoms only of mild character

Technique of Operation—A paramedian incision is generally to be

preferred and since duodenal perforations are much more frequent than gastric perforations the incision should be on the right side Generally an incision 3 in in length and extending up to the costal margin is adequate The rectus muscle may be dissected free within its sheath and retracted *but often it is more conveniently* split in the line of its fibres about ½ in from its medial border

When the peritoneum is opened the diagnosis is confirmed by the escape of gas and often by the presence of a fluid exudate

The site of perforation is sought its position being recognised by the presence of induration and of inherent fibrin flakes in the region of the leak The anterior wall of the first part of the duodenum is examined first then the stomach close to the lesser curvature If no perforation can be found here the second part of the duodenum should be inspected and then the posterior wall of the stomach which can be

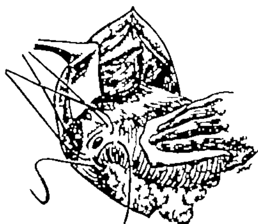


FIG 285

Closure of perforated duodenal ulcer: first suture embraces perforation, others are inserted through healthy seromuscular tissues to either side



FIG 286

Closure of perforated duodenal ulcer sutures drawn tight, omental graft being applied.

exposed by gaining access to the lower sac through an opening in the gastrocolic omentum If still unsuccessful the incision should be extended downwards to the right of the umbilicus and the lower abdomen explored.

Closure of the perforation must be careful and complete Fine catgut sutures (size 2/0) are used It is important to remember that the surrounding tissue is indurated and yet friable and stitches introduced into it will readily cut out Accordingly the needle should be inserted at a distance from the perforation into healthy tissues

The first stitch introduced should pass either directly through or over the perforation and may be left long temporarily to act as a guide More stitches are then inserted to appose healthy peritoneal surfaces and form a secure barrier against further leakage Finally a tag from the adjacent omentum should be stitched in place over the suture line as an extra safeguard

In a perforated duodenal ulcer there is *rarely much difficulty* in effecting a watertight closure In a perforated gastric ulcer on the

other hand the orifice may be so large and the surrounding induration so extensive as to render closure difficult In these circumstances it is sometimes necessary to mobilise a strip of tissue from the lesser omentum and suture it carefully in place to plug the perforation

Any peritoneal exudate is then evacuated by suction or swab and the wound is closed In the rare circumstances in which drainage of the peritoneal cavity is necessary the drain should be inserted in the midline above the pubes A convenient method is to cut down on the point of a curved forceps passed down from the main wound and projected forwards in the middle line Through the stab wound made in this way a rubber tube or preferably a strip of dental rubber is

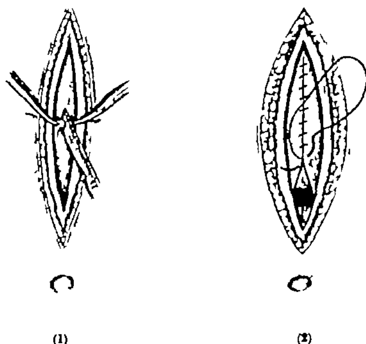


FIG 287

Midline epigastric incision. (1) Skin and linea alba divided; peritoneum held up and about to be incised. (2) The closure. Continuous suture for peritoneum.

inserted down towards the pelvic floor It should usually be left in place for several days and then withdrawn gradually

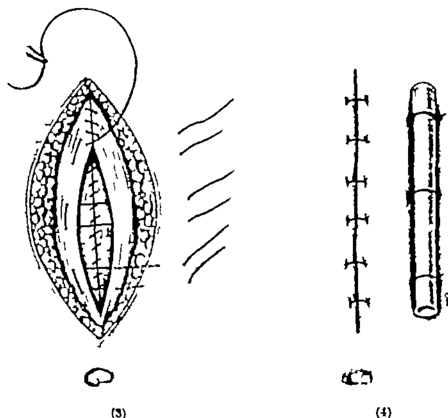
Pre-operative and Post-operative Care—In view of the urgency of operation preparatory measures must be reduced to the minimum A full dose of morphine should be given to relieve the agonising pain and atropine for premedication No enema is required and the skin preparation (a dry shave followed by application of iodine) should be delayed until anæsthesia has been induced

After operation the treatment is similar to that for other operations on the stomach. Fluids (saline glucose proteins or blood) should be given intravenously as required A tube should be passed into the stomach by the nasal route and left *in situ*, with continuous suction

for the first few hours. Water may be given by the mouth from the first. Feeding is begun as soon as the appetite returns, usually on the second day, and thereafter the diet is built up rapidly.

The main complication is pulmonary collapse, which is of great frequency but fortunately free from danger to life. In cases coming to operation late, paralytic ileus, residual abscess, subphrenic abscess and other complications of peritonitis must be looked for.

Conservative Treatment of Perforated Ulcer.—At operation it is frequently noted that the perforation is already plugged or closed by gummy adhesions of neighbouring viscera, and it is clear that in such



(3) (4)

FIG. 288

Midline epigastric incision. (3) Peritoneum closed; deep silkworm sutures inserted from left side; continuous suture of linea alba begun. (4) Wound closed; deep sutures tied over rubber tube.

cases a satisfactory result could have been achieved without operation, provided that measures had been taken to keep the part at rest and prevent further leakage.

Spontaneous sealing-off of a perforation cannot, of course, be relied upon, and consequently the routine adoption of non-operative methods of treatment has proved disastrous. Under circumstances in which operation cannot be performed, however—for example, at sea or under war conditions—such conservative methods should be adopted. Morphine is given in adequate doses not only to relieve pain but also to immobilise the abdomen. Glucose saline is given intravenously. Penicillin and sulphonamides are administered. If a stomach tube is available, the stomach should be emptied immediately and later kept

empty by continuous or repeated aspiration By this method there is a prospect of a favourable result in a fair proportion of cases

The Bleeding Ulcer

The urgent treatment of actively continuing hæmorrhage from an ulcer is a problem to which there is no acknowledged solution There is wide divergence of opinion and some condemn operation while others favour its use in many cases It is accepted that conservative treatment leads to cessation of the bleeding in the majority of patients especially in the younger age groups but in an increasing proportion of older patients the bleeding continues or recurs and leads to extreme exsanguination and death In these cases it is clearly desirable that an attempt should be made to ligate the bleeding vessel

The difficulties involved must not however be underestimated First it must be remembered that hæmatemesis or melæna may result from many pathological conditions other than ulcer—cirrhosis blood dyscrasias splenic disorders carcinoma acute gastritis etc.—and operation should be restricted to cases where the previous history gives no room for doubt as to the diagnosis The second difficulty is to recognise at a sufficiently early stage which cases will fail to respond to conservative measures

It must be conceded that at the present time we have no reliable method of making this distinction There are however certain *general considerations which may serve as a guide*

Hæmorrhage from an acute ulcer is less likely to be severe than from a chronic ulcer in which a large vessel may be eroded and held rigidly open in scar tissue Consequently operative treatment is to be favoured mainly in patients who give a long history of indigestion It is also well established that hæmorrhage is much more likely to be fatal in an elderly person than at an earlier age consequently operation is to be favoured mainly in patients over fifty years of age

The initial hæmorrhage is only rarely fatal and generally subsides spontaneously Danger arises only if this early frank loss of blood is succeeded by a steady persistent ooze or by a series of fresh bleedings For this reason when a patient is admitted to hospital with a bleeding ulcer it is a sound policy to advise conservative measures in the first place If however after forty-eight hours the bleeding is thought to be continuing or if later a fresh hæmorrhage arises these are good reasons to recommend operation

It must be recognised that if operation is to be successful it *must not be delayed until the patient is in extremis* This is particularly important when the bleeding has continued for several days In the immediate phase after a massive hæmorrhage by administering a sufficient amount of blood the patient s condition can be restored to something approaching the normal but after several days oozing no form of treatment is completely effective and massive transfusion may even be dangerous for now the myocardium is flabby and other vital organs impaired owing to the long continued anoxia and perhaps to uræmia and other secondary changes

The operative technique must vary according to the cause of the bleeding and the general condition of the patient A bleeding gastric ulcer is generally treated best by partial gastrectomy but in a bad risk case one may be content with ligature of the main vessels supplying the region of the ulcer For arterial ligation to be effective it must be thorough The left gastric artery should be ligated as it approaches the stomach the right gastric artery immediately above the pylorus and the gastro-epiploic vessels also well to either side In addition all visible tributary vessels in the vicinity of the ulcer should be under run with a stitch A similar procedure may be carried out in cases where despite careful search the precise origin of the bleeding cannot be determined (gastrorrhaxis)

In bleeding duodenal ulcer it is now established that the operation of choice is gastrectomy Such procedures as were formerly adopted, such as gastrojejunostomy alone or with closure of the pylorus are no longer recommended Unfortunately gastrectomy may be far from easy since the ulcer (nearly always situated posteriorly) is often a penetrating one adherent to the gastroduodenal artery and buried in soft vascular adhesions

HOUR-GLASS CONTRACTURE OF THE STOMACH

Hour-glass contracture may result from simple ulceration or from malignant ulceration It is rare as a congenital deformity

Hour glass contracture due to cicatrisation of a simple ulcer saddling the lesser curvature occurs mainly in elderly people especially

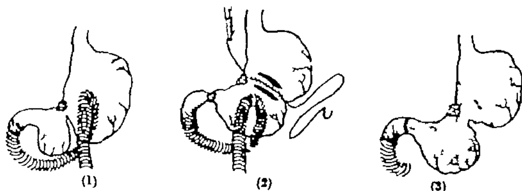


FIG 280

Hour-glass contracture of stomach. Three methods of treatment.
(1) Gastrojejunostomy to upper pouch. (2) Gastrogastrostomy with gastrojejunostomy to lower pouch. (3) Partial gastrectomy

women The most satisfactory treatment is to perform a partial gastrectomy and this should be the method of choice almost as a routine in skilled hands If resection is rendered difficult as a result of the high situation of the ulcer an *anastomosis* may be performed between the upper and lower gastric pouch (gastrogastrostomy) or between the upper pouch and the jejunum A stenosing pyloric ulcer may be present in addition necessitating a further anastomosis between

the lower pouch and the jejunum Hour-glass contracture *due to* malignant ulceration is treated by gastrectomy when possible The rare congenital variety is treated by gastrogastrostomy

CARCINOMA OF THE STOMACH

Carcinoma of the stomach is one of the commonest of new growths and one of the least amenable to treatment Being of insidious onset and with no characteristic early symptoms it does not lend itself well to early diagnosis Consequently when first seen the disease often is too advanced for operation while in those cases deemed suitable for laparotomy it is often found to be too advanced for radical resection Nevertheless since surgical extirpation offers the only hope it should always be advised unless there are clear contraindications

In recent years two important advances have been made in the surgical treatment of carcinoma of the stomach In the first place it is now recognised that often the disease spreads far more extensively in the stomach wall than is seen on naked eye examination and as a consequence a more radical removal of the stomach is advocated Some surgeons indeed believe that nothing short of complete gastrectomy is adequate

In the second place the advantages of the thoracic (transpleural) route have now been established It is recognised that for carcinoma of the cardia the access gained through the thorax is better than by the usual abdominal approach and indeed some surgeons believe that the thoracic route is alone adequate even for total gastrectomy

Resection of the stomach is sometimes advisable even in the presence of metastases for in this way bleeding from and infection of the ulcerating growth are eliminated Other palliative procedures such as gastrojejunostomy are generally not worth while for they carry a high mortality rate and give relief for only a short time Only exceptionally is a short circuiting operation advisable in the presence of a small growth with a severe degree of pyloric stenosis

Clinical Examination —Before operation is advised a full examination must be carried out in an attempt to determine operability If the growth is palpable its mobility or fixity to adjacent viscera may be assessed. It is sometimes stated that a carcinoma of the stomach which has reached the stage of being palpable is almost certainly inoperable but this statement is liable to many exceptions Indeed often the bulky massive tumour is less invasive than the small infiltrating type

X ray examination is valuable in determining the site of the growth and the amount of stomach involved and enables the surgeon to decide how wide a resection will prove necessary

Careful examination must be made for distant metastases The liver is palpated for enlargement or nodularity The presence of free fluid in the abdomen will indicate peritoneal metastases Secondary growths on the pelvic floor or (in the female) on the ovaries may be palpated on rectal or vaginal examination The root of the neck should be examined (particularly the left side) for enlarged glands in

this situation As a routine X ray examination of the chest should be carried out, while if suspicion is aroused by the occurrence of pain X ray examination of the skeleton should also be performed

Pre-operative Preparation —A patient with carcinoma of the stomach generally is in poor condition owing to toxic absorption from the infected growth to bleeding from its ulcerated surface, or perhaps to pyloric obstruction Consequently special measures may be required to prepare him for operation The fluid balance may need to be rectified by intravenous administrations of saline and glucose solution while intravenous protein plasma or blood is often advisable The stomach should be washed out on several occasions particularly if pyloric stenosis is present Penicillin should be given parenterally for three or four days to diminish sepsis while in addition it is useful to apply penicillin locally by instillation into the stomach after gastric lavage

Methods of Gastrectomy for Carcinoma —1 Partial gastrectomy by the abdominal route was formerly the almost invariable method and is still practised by most surgeons for growths limited to the pyloric part of the stomach In general the technique is similar to that of gastrectomy for ulcer except that special care is necessary to ensure wide removal of the regional glands particularly those along the left gastric artery and in the subpyloric group Many surgeons also remove the whole of the greater omentum which may be the seat of metastatic growths spread by the transcœlomic route To do this the omentum is drawn upwards and separated from the front of the transverse colon by delicate knife dissection

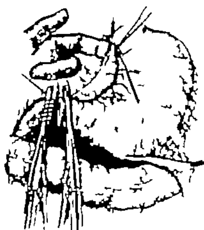
2 The thoracic route is now being adopted as a routine for carcinoma involving the body or cardiac end of the stomach and also where total gastrectomy is proposed It has the advantage of giving free access to the cardia and œsophagus and thus makes mobilisation easier and facilitates the anastomosis between the œsophagus and the stomach or jejunum The technique is very similar to that required for resection of the œsophagus so the two may be considered together (see also p 466)

Transpleural Resection of Œsophagus and Cardia —Different methods may be adopted according to the condition of the patient and the situation of the growth. Sometimes it is wise to explore the abdomen as a preliminary step to determine the extent of spread and in particular to exclude metastases in the liver If this is done and it is decided to proceed the abdominal wound may be closed, the patient turned on his side and a separate incision made in an intercostal space Alternatively the abdominal incision may be enlarged upwards and to the left over the costal margin and along an intercostal space and thus into the pleural cavity with division of the costal cartilage and the diaphragm This method gives a very wide abdominal and thoracic exposure but not much better than the transpleural route alone and as the amount of shock is considerably greater it is not widely practised

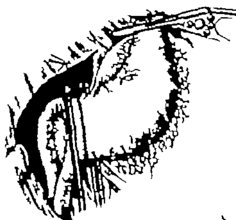
In many cases it is possible to dispense with preliminary inspection of the abdomen and proceed at once to the pleural approach This method has the disadvantage that in a certain proportion of cases where



(1)



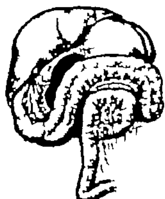
(2)



(3)



(4)



(5)

FIG. 290

Partial gastrectomy for carcinoma of stomach (Polya technique) (1) Omentum being detached from colon. Extent of resection indicated. ( ) Duodenum divided between crushing clamps. Lesser omentum divided. Ligature being applied to coronary artery To close the duodenal stump a continuous suture is applied loosely as shown and pulled tight after removing the clamp. Invaginating stitches are then applied. (3) Pylorus drawn forwards and to left, exposing posterior wall of stomach. Jejunum brought up through opening in mesocolon and approximated to stomach by first seromuscular suture. (4) Jejunum opened. Stomach being cut across. (5) Anastomosis completed and drawn down through mesocolon. Edge of opening in mesocolon sutured to stomach

the growth proves to be too extensive for removal the patient is submitted to a needless thoracotomy but this is outweighed by the advantages gained in operable cases.

The actual procedure varies If the growth is limited to the œsophagus the usual plan is to resect the whole œsophagus from the cardia to above the growth and to implant the œsophagus into the fundus of the stomach which has been mobilised upwards into the thorax It is sometimes advised that the jejunum should be used in preference to the stomach owing to the risk of secondary peptic ulcer of the œsophagus caused by reflux of gastric contents but this risk is not great and on the whole the balance seems to be in favour of an œsophago-gastrostomy In carcinoma of the cardia a similar plan may be followed The stomach is cut across below the growth and the cut margin closed, and the œsophagus is implanted below this level This can only be done if the gastric involvement is slight If much of the stomach is to be removed the œsophagus must be anastomosed to a loop of jejunum

Pre-operative Preparation—Careful preparation is necessary If the patient is able to swallow he should be put on a high calorie diet for a week or two while the protein intake may be enhanced by intravenous administration of casein hydrolysate If dysphagia is present and the patient s condition is poor a preliminary *gastrostomy* of jejunostomy may be performed In addition the routine methods of preparation will be carried out including the transfusion of blood and fluid infusions where necessary

Particular attention must be paid to the prevention of infection For several days pre-operatively the œsophagus, which is usually somewhat dilated should be washed out and penicillin 50 000 units instilled Parenteral penicillin should also be given for two or three days pre-operatively and during the last twenty four hours parenteral streptomycin may be added

Operative Technique—1 The anæsthetic (cyclopropane for choice) should be given by intratracheal intubation An inflatable cup on the tracheal tube is an advantage to give exact control of intrabronchial pressures and to enable the lung to be inflated as required In a long operation periodic inflation of the lung may be advised to reduce the risk of post-operative complications.

The patient is placed in the right lateral position with the scapula drawn upwards A kidney bridge or pillows may be placed under the patient to open out the left rib spaces

The incision is made along the line of the 7th or 8th rib which is resected over a wide extent from the angle posteriorly forwards to the costal cartilage The pleural cavity is thus opened through an incision at least 8 in in length. If insufficient access is obtained the ribs above and below may be divided at the posterior end of the wound and shingled Rib retractors are inserted. The lung is allowed to collapse The pulmonary ligament is divided to expose the posterior mediastinum The lung is then packed upwards under a wet towel.

The extent of the disease is now explored. The œsophagus may be palpated in the lower part of its course The œsophageal orifice in the

diaphragm is defined and an incision made through the diaphragm from this point forwards and laterally In this way access is gained to the abdomen through which the liver and the glands along the lesser curvature may be palpated

The next stage is to mobilise as much of the stomach and œsophagus as is necessary The œsophagus is mobilised with little difficulty for it has few connections in the thorax apart from a number of small vessels reaching it from the descending aorta and intercostal arteries These vessels are readily demonstrated and ligated. In the course of mobilisation the vagus nerves are divided below the level of the lung roots Care must be taken to avoid damage to the right pleura and to the azygos vein The thoracic duct comes into close relationship with the œsophagus in the upper part of the thorax and should be avoided if injured it should be ligated to prevent the development of chylothorax The only real difficulty arises at the level of the growth which may involve the pleura and mediastinal tissues Eventually the œsophagus may be completely mobilised from the diaphragm up to the level of the manubrium sterni

To mobilise the stomach the greater curvature is taken first and freed by dividing the gastrosplenic and gastrocolic omenta This process must be carried out in deliberate steps ligating in turn the vasa brevia and the left gastro-epiploic vessels and their branches Sometimes the spleen must be removed too if it is involved in the growth in which case the lienorenal ligament with its contained splenic vessels must be divided Attention is now turned to the lesser curvature and at this point the left gastric artery is divided close to its point of origin from the cœliac axis In this way the stomach is mobilised down to within an inch or two of the pylorus It should be noted that the stomach has a very extensive intramural vascular anastomosis which affords an ample blood supply to the fundus from the vessels at the pyloric end

The procedure now varies according to the precise situation of the growth If it is limited to the œsophagus, the lower end of the œsophagus is divided at the cardia and the opening into the stomach closed Proximally the œsophagus should be divided a full inch above the visible margin of the growth Great care must be taken in this and the succeeding stages of the operation to avoid contamination of the mediastinum and pleura from the infected œsophagus The œsophagus must now be anastomosed to the fundus of the stomach If a long section of the œsophagus has been removed it is necessary to take the stump of the œsophagus up beyond the aortic arch and bring it out into the left pleural cavity above this point in order to free sufficient for the anastomosis The actual anastomosis is made between the end of the œsophagus and a small incision in the anterior wall of the fundus of the stomach For the anastomosis fine silk should be used and particular reliance is placed on the line of sutures attaching the mucous membranes for in the œsophagus this is the only layer which takes kindly to suturing The outer layer of muscle fibre with its longitudinal fibres is very apt to tear The actual plan of anastomosis varies The usual method is to insert a continuous suture uniting the mucous

layers and to supplement this by interrupted sutures attaching the serous coat of the stomach to the outer layer of the œsophagus The fundus of the stomach may then be drawn forward from each side to envelop the anastomosis and finally omentum may be attached to give greater security

If the growth involves the cardia the greater part or whole of the stomach must be removed along with the lower œsophagus continuity being restored by anastomosis with the jejunum The jejunum is divided at a suitable point a few inches from its upper end the distal part being mobilised to allow it to be brought up into the thorax. Care must be taken to preserve the blood supply to this segment and it is dangerous to divide more than three of the major arterial arcades supplying this part of the gut An anastomosis en Y is then made between the two jejunal loops

At this stage the opening in the diaphragm is closed around the stump of stomach or jejunum These viscera should be attached to the diaphragm by interrupted sutures to prevent prolapse The phrenic nerve may be picked up as it courses over the pericardium and crushed to provide temporary paralysis of the diaphragm At this stage also it is useful to inject proctocaine into the posterior ends of the three or four interspaces at and above the level of incision to diminish after pains The chest wound is then closed. A drainage tube is left in position or preferably, inserted by means of a stab wound through a lower interspace to drain the pleural cavity This tube which should be of large size is carried down to below the surface of fluid to act as a waterseal drain.

Post-operative Care—A transnasal gastric tube should be inserted past the anastomosis at the conclusion of the operation For two or three days constant suction is applied to the tube to minimise the risk of reflux and leakage at the anastomosis Thereafter the tube may be used for feeding the patient by a continuous milk drop During the immediate post-operative period blood transfusion and continuous intravenous drip infusion may be required Penicillin and streptomycin should be continued by the parenteral route for several days The pleural drain should be left in position for ten or twelve days

C F W I.

REFERENCES

ALLAN A. A., and WELCH, C. E. (1946). "Subtotal Gastrectomy for Ulcer *Ann. Surg.*, 124, 688.

ALLISON P R. (1946). Peptic Ulcer of the Œsophagus." *J thorac. Surg.*, 15, 308.

AVERY JONES, F (1947). "Hæmatemesis. *Brit. med. J.*, 2, 441 477

BARBER, R. F and MADDEN J L. (194). "Surgical Management of Gastrojejunocolic Fistula. *Surgery* 22, 657

CUTTER, M. D., BUTT H. R., and WAUGH, J M (1946). "The so-called Dumping Syndrome of the Subtotal Gastrectomy *Ann. Surg.*, 123, 410

DORAN F S A. (1947-48). "The Surgical Treatment of Anastomotic Ulcer *Brit. J Surg.*, 35, 377

DRAGSTEDT L. R., and SCHAFER, P W (1945). "Vagotomy in Gastroduodenal Ulcer *Surgery* 17 742.

DRAGSTEDT L. R., *et al* (194). "Vagotomy in the Treatment of Peptic Ulcer" *Ann. Surg.*, 126, 687

ILLINGWORTH, C. F W (1947). "Perforated Peptic Ulcer. *Practitioner* 158, 24.

ILLINGWORTH C F W (1948). "The Surgical Treatment of Peptic Ulcer Glasgow med J., 29 157
IRVINE, W T (1948) Postprandial Syndrome after Partial Gastrectomy Brit. med. J., 2, 514
MARSHALL, S. F (1945) A Plan for the Surgical Management of Gastrojejunocolic Fistula." Ann. Surg 121, 020
PACK G T., et al (1948) Symposium on Cancer of Oesophagus and Cardia. Surgery 22, 807 1 010
PFEIFFER, D B. (1941) Surgical Treatment of Gastrojejunocolic Fistula. Surg. Gynec. Obstet., 72, 282.
SCHAEFFER, A. A., and ERBES J (1948). "Hypertrophic Pyloric Stenosis. Surg Gynec. Obstet 86, 45.
ST JOHN F B., HARVEY H. D et al. (1948). "Gastrectomy for Ulcer Ann Surg 128, 3.
SWEET R. H. (1946) "Subtotal Oesophagectomy Surg Gynec. Obstet., 83, 417
WELLS C. and BREWER, A. C. (1947-48) "The Surgery of Duodenal Ulcer Brit J Surg., 35 364

CHAPTER XXXIII

AFFECTIONS OF THE INTESTINES

INTESTINAL OBSTRUCTION

INTESTINAL obstruction may result from a great variety of conditions it may affect the small or large intestine and it may be acute or chronic The treatment varies in some respects in these different circumstances but there are certain principles which while especially important in acute small intestine obstruction require attention in all cases

Acute Obstruction of Small Intestine

In acute obstruction of the small intestine operation while almost always necessary and often demanded urgently must be delayed until pre-operative treatment has been carried out Adequate pre paration will transform an almost moribund patient into one reasonably fit for operation its omission will court disaster

Pre-operative Preparation—Gastric lavage must always be carried out to relieve the distended stomach—and thus eliminate an important cause of shock—and to obviate the considerable risk of inhaling vomited material during operation A No 10 stomach tube should be used in preference to a narrow bore duodenal tube which is apt to become blocked. The stomach is emptied and washed out with saline Continuous suction is then established using either an electric suction motor or a syphonage apparatus and is maintained before during and for twenty four hours or so after operation If the tube is intro duced by way of the nose it is well tolerated even in children and its value is very great

Intravenous infusions of saline and of 6 per cent glucose are required to combat the alkalosis and dehydration to restore the blood chlorides and replenish the liver glycogen The amount of saline required will depend upon the degree of hypochloremia and, when that has been corrected additional fluid requirements are supplied in the form of 6 per cent glucose The amount depends on the degree of dehydration and may total 3 or 4 litres or even more If all this fluid was given in the form of saline there would be serious danger of producing œdema hence the need for differentiating between saline and glucose infusions

Morphia may be given during the period of waiting (provided that the decision to operate has been made and that the masking effect of the drug is borne in mind) The bladder should be emptied if necessary by catheter

The choice of anæsthetic must depend on the condition of the patient Provided the blood pressure is not too low a spinal anæsthetic will be found to be ideal, for it gives perfect relaxation and to a large extent avoids the tendency for distended coils of intestine to escape from the abdomen during the exploration It has the added advantage that it does not inhibit intestinal movements which continue unabated when the abdomen is opened

In selected cases intestinal decompression by suction combined with adequate fluid replacement may relieve the obstruction completely

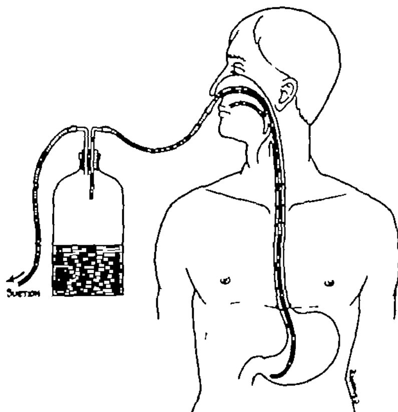


FIG. 291

Gastric drainage The nasal catheter is attached to an electric suction apparatus to maintain continuous drainage of the stomach.

and render operation unnecessary This method should be employed in all cases of paralytic ileus and in the presence of a simple mechanical obstruction of the small intestine It is contraindicated in all strangulation obstructions and therefore before this form of treatment is under taken an accurate diagnosis of the type of obstruction is essential

Simple and strangulating obstructions both cause colicky abdominal pain and vomiting but while the former rarely causes irritation of the parietal peritoneum a strangulating lesion does If therefore abdominal examination reveals localised tenderness and some rigidity in association with the symptoms of small bowel obstruction operation should be undertaken promptly Diagnostic difficulty may occur in those cases where an inflammatory mass is causing simple obstruction of the bowel The signs may simulate a strangulation so closely that its differentiation may prove to be impossible

Operative Treatment—When the cause of the obstruction is unknown a right paramedian incision in the lower abdomen is most satisfactory This site is chosen because here both ileum and cæcum can be examined with a minimum of handling and evidence obtained as to whether the obstruction is in the small or large intestine Further it will be found that in a large proportion of cases the obstruction can be located and relieved through an incision in the right lower quadrant In the first instance the incision should be long enough to admit only the exploring hand which may conveniently be lubricated with vaseline Later when the nature of the obstruction has been ascertained it may be enlarged upwards or downwards as seems necessary

The cæcum and terminal ileum are now examined Distension of the cæcum will point to an obstruction of the large bowel while the presence of an empty cæcum and collapsed terminal ileum is strong presumptive evidence of a small bowel obstruction It must be kept in mind that if the ileocæcal valve is incompetent a large-bowel obstruction may cause distension of both cæcum and terminal ileum The presence of a peritoneal effusion should be noted A clear peritoneal exudate is usually present when there is marked intestinal distension, while a blood-stained exudate suggests some form of internal strangulation or a mesenteric thrombosis. A seropurulent exudate points to an active inflammatory cause of the obstruction while the typical odour of *Bacillus coli* generally indicates secondary gangrenous changes in the bowel.

If as is usually the case the exact site of the obstruction in the small intestine is in doubt the collapsed terminal ileum is traced upwards until the junction between the collapsed and distended bowel is encountered and the cause of the obstruction ascertained While making this examination it is most important that the intestines be handled with the greatest care Distended coils of bowel should not be brought outside the abdomen except when unavoidable as occasionally in volvulus (where it is necessary to determine the nature of the rotation and facilitate its reduction) in such cases the intestine must be protected by warm moist towels

Difficulty may be experienced in deciding to which part of the intestine a given loop belongs and distinguishing the afferent from the efferent loop The jejunum can be distinguished from the ileum by its less fat laden mesentery and more distinct vessels of which the vasa recta which pass from the arterial loops to the bowel are much longer and more obvious than in the lower reaches of the intestine The disposition of the intestine can be recognised by the oblique lie of the base of the mesentery

When the obstructing lesion has been found the procedure required to relieve it will depend on the nature of the condition A strangulating adhesion or band must be divided and if possible removed and the bowel examined for evidence of gangrene Particular attention must be paid to any constriction ring as it is here that necrosis is particularly liable to occur A small area of necrosis may be invaginated but if the intestine is frankly gangrenous enterectomy or exteriorisation must be carried out If there is doubt as to its viability the affected loop

should be wrapped in warm towels while oxygen in high concentration is administered by inhalation if the colour of the suspect bowel improves rapidly its circulation may be regarded as adequate

The intestine may enter a retroperitoneal pouch such as occurs in relation to the duodenum or the cæcum it may traverse a congenital orifice in the mesentery pass through a snare formed by an adherent band or insinuate itself through the *mesocolon alongside a gastro* jejunostomy stoma A considerable length of intestine may thus be herniated Before reduction can be effected it is often necessary to divide the constricting ring and this must be done with great care as important vessels may lie in relation to it Thus in left paraduodenal *hernia the* inferior mesenteric vein is a very close anterior relation of the neck of the *fossa Equal care must be taken* when the mouth of the fossa is being obliterated

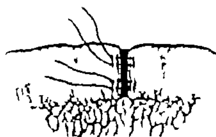


FIG 292
Acute intestinal obstruction Constriction ring being invaginated

When it is found that the obstruction is due to extensive matting of the intestines by adhesions no attempt must be made to separate such adhesions for the intestines are very liable to be damaged, with the consequent risk of peritoneal contamination and moreover the adhesions will inevitably form again Instead an anastomosis should be made between the bowel above and below the obstructed segment It may be possible to do an entero anastomosis but more often it is better to anastomose the dilated small bowel to the transverse colon (ileo-transverse colostomy) A similar procedure may be required if the obstruction is found to be due to multiple tuberculous strictures

ACUTE OBSTRUCTION OF THE COLON

Acute colon obstruction is generally due either to volvulus or *(much more commonly)* to carcinoma In volvulus which may affect the cæcum or the sigmoid colon, the obstruction usually develops suddenly and prompt relief is required for interference with the blood supply may *lead rapidly to gangrene In carcinoma the obstruction* usually develops more slowly and often is superimposed upon a gradually increasing chronic obstruction In either case there is seldom the severe degree of dehydration and alkalosis characteristic of small bowel obstruction.

Unless urgent operation is imperative an attempt should be made to determine the nature and site of the obstructing lesion The history and abdominal examination may offer some guidance Rectal examination should always be performed and sigmoidoscopy is valuable in cases of volvulus or carcinoma of the pelvic colon. A simple radiograph preferably taken with the patient in the upright position will show gas-distended coils and assist in locating the lesion. Finally X ray examination after administration of a barium enema will clinch the diagnosis.

In some cases when the ileocæcal valve is incompetent the distension involves not only the colon but small bowel also and the clinical features may stimulate a simple obstruction of the ileum If as is more usual the valve is competent the cæcal distension may become so marked as to cause interference with its blood supply Tenderness and rigidity will be noted in the right iliac fossa and delay in relieving the obstruction may result in perforation of the cæcum

When the nature and site of the lesion are known the operation may be planned accordingly thus for volvulus a paramedian incision is required, for carcinoma a colostomy is performed its site depending upon the position and resectability of the growth (p 611)

When the nature and site of the lesion are not known the choice lies between exploring the abdomen through a paramedian incision and performing a blind cæcostomy Exploration should be carried out where practicable but if there is marked intestinal distension with risk of prolapse and rupture of a distended loop during the operation, or if the patient is in poor general condition a blind cæcostomy is preferable for it is a simple procedure involves little risk and relieves the obstruction whatever the site of the lesion

Paralytic Ileus

This condition is essentially one which involves the small intestine though the colon may be affected to a lesser degree To appreciate the indications for treatment the primary condition responsible for its development must be kept in mind Paralytic ileus most often follows closely upon operation for acute appendicitis with peritonitis or upon resection of a portion of small intestine It may also develop after fracture of a long bone after injury to the spine (especially if manipulative treatment has been performed) or occur in association with pneumonia The ileus is due mainly if not entirely to inhibition of the gut musculature perhaps due to overactivity of the sympathetic nerve supply to the bowel There is thus no organic obstruction requiring relief and if the distension and such secondary effects as dehydration and salt-deprivation can be corrected the bowel will generally recover from its paralytic state

Paralytic ileus resembles organic intestinal obstruction in respect that there are abdominal distension persistent vomiting and complete constipation but differs in that there is no intestinal colic and the abdomen is quiet on auscultation These latter features are indications for conservative rather than operative treatment

In the treatment three objects must be achieved the distended small intestine must be decompressed the water balance must be maintained the intestines must be given rest No attempt whatever is made to stimulate the paralysed bowel and the administration of pituitrin or similar bowel stimulants is therefore contraindicated.

Intestinal decompression can be attained most efficiently by means of the Miller Abbott tube or one of its modifications This consists of a 10 ft double-lumen rubber tube to which a small rubber balloon (30 c c capacity) is attached just proximal to the opening at the tip

The tube is introduced through the nose and when it reaches the nasopharynx the patient takes sips of water and the tube is gently passed down the œsophagus for a distance of twenty inches by which time it should be in the stomach Suction is applied until the stomach is empty then the patient is turned on the right side and more water is given by mouth while the tube is slowly advanced about an inch every five minutes In a successful case the duodenum will be reached in about half an hour and the balloon is then inflated and the tube is slowly carried down the intestine Continuous suction is carried out and by this means the distended small intestine can be slowly emptied. The blood supply to the bowel is thus improved it regains its tone and peristaltic movements return If this specialised tube is not available an ordinary small stomach tube is passed and gastric suction instituted as has already been described In cases of high intestinal obstruction with gross gastric and jejunal distension the passage of a tube into the duodenum is frequently difficult or impossible In cases of paralytic ileus such gross distension should be prevented by instituting duodenal suction at an early stage and this is perhaps the main essential for the successful treatment of this condition

Paralytic ileus is not overcome rapidly and suction may have to be continued for several days In a successful case the abdominal distension becomes less marked and the aspirated intestinal contents *which at first were dark brown and foul smelling* become lighter in colour If gastric suction has been employed the fluid will become practically clear and the tube may then be removed, but any complaint of a feeling of gastric distension or a recurrence of vomiting is an *indication for the immediate resumption of gastric suction While the* suction is carried out the patient is allowed to take sips of water by the mouth this fluid is of course immediately aspirated but it adds considerably to the patient s comfort Soreness of the throat is often complained of after prolonged gastric suction, but this can be alleviated at least in part by sucking nupercaine lozenges

Fluid must be administered sufficient to replace that withdrawn by suction as well as that excreted as urine and the invisible loss from skin and lungs (p 17) The fluid must contain salt sufficient to restore the chloride level. To estimate the volume required all fluid withdrawn by suction (less any that has been drunk) must be measured and the amount charted, while an accurate note must be kept of the urine secreted Four or 5 litres of physiological saline may be required daily to fill the chloride requirements *If more fluid is needed to* preserve the water balance it should be given in the form of 6 per cent glucose in water for an excess of salt leads to œdema and pre disposes to chest complications. Intravenous fluid therapy must be *continued so long as gastric suction is required*

When this has to be maintained for many days it has been found that benefit is obtained from the daily addition of ascorbic acid and Benerva 1 c c of each This increases the well being of the patient and promotes healing In such cases the intravenous administration of amino-acids may prove helpful but they must be used with caution and given very slowly with saline as brisk reactions may be encountered (See p 16)

Throughout this treatment the patient must be kept at rest, mentally and physically, by an adequate amount of morphia When all the signs point to the ileus having been relieved an enema may be given and if a bowel movement is obtained then and only then is a purgative allowed. It not infrequently happens that the success of the treatment is finally demonstrated by the bowels moving spontaneously If despite conservative treatment the ileus persists or increases jejunostomy may prove necessary Formerly this operation was performed frequently but it is now required but rarely for in most cases intestinal decompression and drainage can be achieved with equal success and greater safety by the non-operative procedures

OPERATIONS FOR DRAINAGE AND RESECTION OF SMALL INTESTINE

Enterotomy

This procedure consists in opening the small intestine for the removal of a gall-stone or other foreign body In such cases the patient is often in poor condition as a result of delay in diagnosis and the operation may have to be done under local anæsthesia

The loop of bowel containing the foreign body is brought out of the abdomen and surrounded by moist towels to guard against contamination of the wound If the foreign body is impacted it should if possible be milked upwards into the distended bowel The loop to be opened is gently compressed to express its contents and a light clamp is applied. A small incision is made in the long axis of the bowel and the foreign body removed Peritoneal forceps are placed on each edge of the incision at its mid point and gentle traction converts the longitudinal incision into a transverse opening which is then closed by two rows of sutures The first suture passes through all the coats of the intestine and the second, a Lembert suture approximates the peritoneum over the line of closure

Enterotomy has been employed with the object of emptying grossly distended intestine In such cases a small Paul s tube or a No 14 catheter is inserted into the bowel and secured by a purse-string suture Such a tube will drain only a very limited segment of bowel and to secure more complete emptying it is necessary to milk the intestine between the fingers This entails a great deal of handling and is likely to result in a marked degree of *ileus* For this reason, and in view of the possibilities of intestinal decompression by duodenal tube the operation is not recommended.

Enterostomy Jejunostomy

This operation is indicated (*a*) for temporary drainage of the distended jejunum in certain cases of post-operative intestinal obstruction and paralytic ileus when conservative measures have failed (*b*) occasionally to feed the patient when it is desired to put the stomach at rest

for example in severe gastric or duodenal ulceration In such cases excellent results are obtained by administering a continuous reinforced milk drip through the jejunal tube

A short vertical incision is made on the left side above and lateral to the umbilicus retracting the rectus muscle laterally General anæsthesia is preferable but in post-operative obstruction or ileus it is *often advisable to use local anæsthesia* A loop of proximal jejunum should be chosen for drainage since under the conditions in which jejunostomy is usually performed, the lower coils of intestine are generally inflamed adherent or paralysed and thus incapable of discharging their content

If possible the duodeno jejunal flexure is identified at the root of the mesocolon and the drainage established about a foot below this point

The loop chosen for drainage is brought up to the wound and a *light clamp applied* A fine catgut purse-string suture is inserted, enclosing a circle about 1 cm in diameter on the antemesenteric border of the intestine A stab opening is then made within the circle and a No 10 catheter inserted into the lumen with care to avoid soiling of the wound by the highly infective intestinal content The catheter is stitched to the edge of the stab wound and the purse-string suture tied The catheter is further embedded by a continuous catgut suture which draws the seromuscular layers of the intestine over it after the Witzel method (Fig 203) The catheter is brought out through a small opening in the omentum which adheres and prevents leakage If this is not possible the jejunum in the vicinity of the drainage opening is stitched lightly to the parietal peritoneum When the abdomen has been closed drainage of the intestine is aided by the use of constant suction.

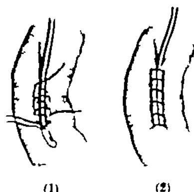


Fig 203

Enterostomy (1) Catheter inserted purse string tied, invaginating suture being inserted. (2) Suture completed

In some cases very large quantities of fluid are discharged and the loss must be made good by intravenous saline infusions Drainage is seldom necessary for more than three or four days and when the tube is removed the fistula heals rapidly

Jejuno transverse Colostomy

In some cases the operation of enterostomy can be replaced by an anastomosis between the jejunum or ileum and the transverse colon This procedure relieves the obstruction and conserves the fluids which are absorbed from the colon The writer s preference is for a jejuno-transverse colostomy *which has proved a life-saving procedure* in a majority of the cases in which it has been employed. Drainage of the jejunal contents into the colon might be expected to give rise to troublesome symptoms jejunal diarrhœa and inanition, but such is not the case At a comparatively early stage the matted intestines

Enterectomy

This procedure implies the removal of a portion of the intestine and is followed necessarily by some form of anastomosis to reconstitute the intestinal tract. Resection is indicated in carcinoma of the intestine, in injuries to the intestine or its mesentery, in carcinoma of the intestine and in strangulated hernia or volvulus. In injuries resection should be carried out only when (a) a segment of bowel has been completely destroyed, (b) there are several large perforations within a short distance of one another, (c) laceration of the mesentery has so damaged the vessels as to endanger the vitality of the bowel. In strangulated hernia and volvulus resection is indicated if the gut is non viable as judged by its matt surface, greyish colour, flaccidity and lack of peristalsis. The inexperienced surgeon is apt to underestimate intestinal viability and to perform resection unnecessarily. If there is any doubt it is usually safe to assume that the intestine is viable and to return it to the abdomen. It is probably true to say that in such cases the risk of enterectomy by an inexperienced operator is greater than the risk of conservative surgery.

When enterectomy is inevitable certain decisions must be made. (1) Can the patient stand what is necessarily a serious operation? A primary resection with anastomosis is certainly ideal but with a gravely ill patient it is better to exteriorise the bowel and resect it at a later stage. (2) How much bowel requires to be excised? This must depend on the cause and extent of the gangrene. If a mesenteric thrombosis is present many feet of bowel may have to be removed. In every case division of the intestine must be carried out through healthy tissue so that an anastomosis can be performed with safety. (3) What form of anastomosis is required to reconstitute the intestinal tract? There are three possibilities.

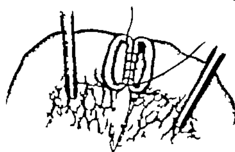


Fig. 205
End to-end anastomosis. Through-and through suture being inserted.

End-to-end union of the intestine achieves the most perfect anatomical result but has certain objections. It is unsuitable when dilated proximal and contracted distal bowel have to be united. The risks of leakage in this type of union are greater on account of the mesenteric space which must be obliterated in order to secure accurate peritoneal apposition. *End-to-side union* is unlikely to be required when dealing with the small intestine alone but may be employed after excision of the right half of the colon when the end of the divided ileum is anastomosed to the side of the transverse colon. *Side-to side* or *lateral anastomosis* is the procedure to be preferred. It is easy to carry out and disproportion in size between the two portions is no bar to the anastomosis.

Enterectomy and Lateral Anastomosis.—The incision to be employed will depend upon the condition to be dealt with. If the gangrenous bowel lies in the sac of a femoral hernia a second incision in the lower

abdomen is generally required The strangulation is released through the hernial incision the bowel is reduced and brought outside the abdomen care being taken to avoid peritoneal contamination In the case of an inguinal hernia the resection can be carried out through the original incision which is enlarged as required In other cases the original exploratory abdominal incision will be adequate

The segment of bowel to be resected is brought out of the abdomen and the wound and peritoneal cavity packed off with moist swabs The bowel is held up to visualise the mesenteric vessels which are then ligated close to the base of the mesentery Each vessel should be divided between ligatures rather than held in haemostats The mesentery is divided towards the bowel so that a V-shaped segment

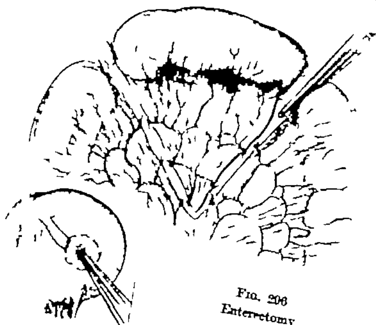


Fig. 206
Enterectomy

is isolated and the lateral branches ligated as may be necessary Care is taken that the blood supply to the portions of intestine to be retained is not damaged A crushing clamp is applied to the bowel at the point previously selected for division and it is slowly crushed The clamp is removed and the crushed bowel ligated with catgut or linen thread A similar procedure is carried out at a distance of 2 cm a moist swab is laid beneath this area and the bowel is divided between the ligatures by cautery or carbolised knife. The other end of bowel to be excised is similarly dealt with and the segment removed The ligated stumps are now secured by placing a purse string linen suture round the bowel about 2 cm from the stump which is invaginated as the suture is tightened One or two additional Lembert sutures may be required to reinforce the closure The two portions of bowel are laid side by side isoperistaltically so that they overlap for about 3 or 4 in. and a lateral anastomosis is completed

Following such a procedure the new anastomosis cannot be expected to function at once and a varying degree of ileus is to be looked for

It will be found therefore that recovery will be easier and more rapid if duodenal drainage be employed for forty-eight hours

Exteriorisation and Resection

This procedure is required only if the intestine is gangrenous and the patient too ill to stand resection with anastomosis Under these conditions this method can be a life-saving measure but the after treatment is often fraught with difficulties and dangers It is not suitable in the case of young children

The gangrenous loop and a few inches of viable bowel on either side of the affected segment are brought out of the abdomen and the wound is closed sufficiently to prevent the escape of other coils of intestine care being taken not to constrict the mesentery of the still viable bowel Strands of iodoform gauze are placed within the wound and surrounding the base of the exteriorised loop This is a minor but important detail in the technique as it greatly facilitates the third stage of the procedure The viable portions of exteriorised bowel proximal and distal to the gangrenous segment are now divided Rubber tubes or large catheters are passed into both portions of healthy intestine until their tips lie well below the level of the abdominal wall (Fig 297) The bowel ends are closed and invaginated round the tubes by a series of purse-string sutures. The intestinal drainage can be collected and is administered into the distal bowel by tube and funnel. If necessary the excision of the gangrenous segment may be delayed for twenty four hours There is little bleeding as the mesenteric vessels are thrombosed Later when the general condition permits the wound is reopened, the bowel ends are excised, ligated and invaginated and the continuity of the tract restored by lateral anastomosis This third stage should whenever possible be carried out on the third or fourth day that is before leakage occurs around the enterostomy tubes, a complication which leads to excoriation of the skin and may result in severe wound infection The risks of peritoneal infection when the wound is reopened are not great, for a local immunity rapidly develops.

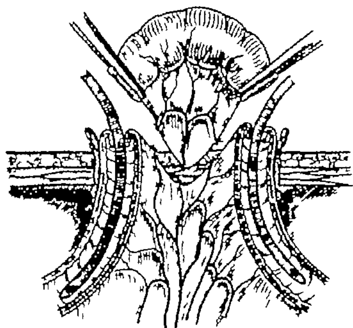


Fig 297
Exteriorisation and resection.

Lateral Anastomosis

As has already been indicated this procedure is employed following an enterectomy It is less commonly used when a portion of colon has been resected, as the greater fixity of the large bowel makes it difficult to obtain the additional length necessary to lay the portions of bowel side by side without tension It is the method of choice as a step in short-circuiting a tuberculous stricture or other obstruction for which enterectomy is not indicated In such a case the entero anastomosis must be placed sufficiently far from the obstructed segment to avoid any risk of its involvement later by an extension of the primary lesion

The portions of bowel to be united are controlled by light clamps which are then placed side by side and secured by clip forceps Moist packs surround the area and shut it off completely from the wound The apposed peritoneal coats are united for a distance of 2½ in. by a continuous seromuscular suture Catgut is generally used but in malignant cases silk or linen is preferred At both ends this posterior serous suture is left long and the needle remains attached to it Each portion of the bowel is opened by an incision placed ¼ in away from the suture line This incision first divides the seromuscular coats the mucosa herniates through the gap and is picked up incised and the lumen entered The incisions should be slightly shorter than the seromuscular suture line The assistant must be ready to catch with swabs any intestinal contents that may tend to escape A through and through suture is next inserted which includes all the bowel coats controls the divided vessels and approximates the mucosa When the end of the suture line is reached the needle is passed from within outwards through the bowel wall and the closure of the anastomosis completed by an anterior through and through suture When this is completed the starting point of this suture has been reached and it is tied off The clamps may now be removed and any bleeding points secured The original seromuscular suture which has been left attached is now continued as an anterior Lembert stitch which buries the previous suture line and ends at its starting point by being tied to the long end which was left for the purpose As a final step reinforcing sutures may be inserted at the ends of the anastomosis in order to give a very secure closure of what are potentially dangerous points All the instruments used in the course of the anastomosis are now discarded and the surgeon and his assistants change their gloves before proceeding with the operation

INTUSSUSCEPTION

This condition in which one portion of bowel is invaginated into the segment immediately distal is one of the commonest causes of intestinal obstruction in young children The intussusception usually arises in the terminal ileum and progresses through the ileocæcal valve and so along the colon. Treatment must be prompt for the longer this is delayed the more difficult will its relief become the

greater will be the chance of gangrene occurring in the invaginated bowel and the more serious will be the child's general condition

Most surgeons are agreed that early operative treatment offers the best results but many cases of successful reduction by such non operative measures as inflation or injection of fluid by the rectum have been reported If this method is employed, barium should be slowly run into the rectum through a tube and the reduction observed under the fluoroscopic screen Only in early cases can reduction be hoped for and even then it is impossible to be quite certain that the reduction is complete This difficulty can be overcome by preparing the child for abdominal exploration and when the intussusception has receded to the ileocæcal region the abdomen is opened through a small incision in the right iliac fossa and the final reduction completed by manipulation

If as is preferred, operative measures are employed the child must be prepared as would any other patient with intestinal obstruction. The abdomen is opened by a paramedian incision in the right iliac fossa Speed is important but not at the expense of gentle handling and the manipulations must be carried out within the abdomen Two fingers are introduced and the intussusception is located the distal part or apex being *compressed and gently milked proximally* Usually reduction does not present much difficulty until the last few inches are reached Only at this stage in the reduction is it justifiable to *bring the bowel into the wound Firm compression of the part with* warm moist towels will lessen the œdema and facilitate the final reduction The temptation to apply traction to the entering intestine *must be resisted lest the bowel be damaged Too much time* should not be spent in repairing any peritoneal tears that may be present after reduction as the bowel is sodden and friable and stitches tend to tear out.

It has been suggested that the starting point of the intussusception should be palpated for signs of a polyp and that if one be found it should be removed Such a procedure *adds to the length of the operation, introduces the risks of peritoneal contamination and therefore* should be postponed until the child has recovered from the primary emergency

If the intussusception is irreducible or gangrenous resection may be *carried out but a lateral anastomosis gives satisfactory* results and is a safer procedure In older children and adults though not in infants exteriorisation may be used instead.

ILEOCÆCAL TUBERCULOSIS

The term ileocæcal tuberculosis includes three *distinct though often* related conditions tuberculosis of ileocæcal lymph nodes ulcerative lesions of the ileum or cæcum, and hyperplastic ileocæcal tuberculosis

In tuberculosis of *ileocæcal lymph glands operation is* called for only occasionally to drain a cold abscess or to relieve secondary intestinal obstruction resulting from pressure by or adhesion to the glands In ulcerative *lesions operation is indicated only* where fibrosis has caused strictures and led to intestinal obstruction and the operation should consist in anastomosing the ileum or jejunum to the transverse

colon to short-circuit the diseased tract Before deciding upon this procedure it is important to examine the whole length of the small intestine to assess the extent of the disease Exceptionally there are multiple strictures extending from the terminal ileum to the duodeno jejunal flexure and in such a case the surgical problem is well nigh insoluble

In hypertrophic ileocæcal tuberculosis where a low-grade infection has led to much thickening and fibrosis of the wall of the gut, the ideal treatment is to resect the proximal half of the colon as for carcinoma If this is technically impracticable owing to fixation of the mass or extensive glandular involvement or if ulcers or strictures of the ileum coexist the small intestine should be anastomosed to the colon It should be realised that such an anastomosis does not place the cæcum completely at rest even when the ileocæcal valve is obstructed as fæcal contents tend to pass backwards from the transverse colon No attempt however should be made to sidetrack the cæcum more completely by combining ileotransverse colostomy with complete division of the ileum for then the blind loop of ileum may become obstructed by later narrowing of the valve

REGIONAL ILEITIS

This condition is primarily an inflammatory lesion of the small intestine sometimes involving both jejunum and ileum but more often confined to the terminal part of the latter In its acute phase it is usually mistaken for appendicitis but at operation the ileum is found to be acutely congested and œdematous and the mesenteric glands are enlarged Perforation may occur with formation of an abscess drainage of which will be followed by a fæcal fistula In the later stages the bowel wall becomes thickened rigid and tube-like and the cæcum may be involved The symptoms and signs are those of subacute or acute intestinal obstruction.

Treatment depends on the stage of the disease In the acute phase nothing should be done as in many cases *spontaneous remission occurs* Ileo-transverse colostomy well above the upper limit of the disease with division of the ileum is the method of choice in obstructive cases or in those where fistulæ have developed In a small proportion of cases the disease remains active in the excluded loop and only in such cases should resection be performed the affected portion of ileum and the cæcum being excised.

Post-operative diarrhœa which is painless and otherwise symptomless is frequently encountered during the first few months following either resection or the short-circuiting operation This troublesome *complication gradually abates* and does not necessarily or usually indicate that the disease is still active

VOLVULUS OF SIGMOID COLON

In this condition the pelvic colon rotates on its mesentery its blood supply is interrupted, and the bowel rapidly distends. In a few hours the combination of vascular occlusion and tension may result in gangrene and peritonitis

The volvulus is exposed by an incision over the lower part of the left rectus muscle but on no account must the distended colon be brought outside the abdomen as without the support of the abdominal wall it may rupture An assistant passes a tube into the rectum and the surgeon s hand within the abdomen endeavours to guide it into the distended loop If this manœuvre succeeds it greatly facilitates the further steps, as the bowel is easily emptied and the twist can be undone If attempts to pass the tube fail the bowel is brought flush with the abdominal wall the peritoneal cavity is packed off and a wide-bore needle, to which a tube is attached, is inserted and the tension relieved The puncture opening is closed with a purse-string suture and the torsion is relieved Even when the obstruction has been overcome a state of ileus exists in the pelvic colon, and it is wiser to make a temporary colostomy Primary resection of an acute volvulus *of the sigmoid is not justifiable so if the bowel is already gangrenous* it must be rapidly exteriorised drained and resected later

Recurrent volvulus of the sigmoid is common and even the fixation which a temporary colostomy gives will not prevent it once that opening has been closed Various plastic operations to fix the sigmoid loop have been devised but they are not altogether successful and should never be employed during an acute phase Resection is the only certain means of preventing recurrence but it should be performed only during a quiescent period.

DIVERTICULITIS

Diverticula occur commonly in the large bowel, especially in its sigmoid portion Symptoms commonly result from infection of the diverticula (diverticulitis) and are similar to those of left-sided appendicitis The inflammation tends to subside spontaneously under conservative measures Operative treatment is difficult, unsatisfactory and not free from danger consequently it should be advised only if conservative measures have failed if suspicion of malignancy exists or in the presence of the following complications (1) perforation of a diverticulum (2) obstruction due to fibrosis of the wall of the bowel (3) fistula between the colon and the bladder

Perforation of a diverticulum into the free peritoneal cavity gives rise to widespread intense peritonitis and is a highly dangerous complication The clinical features may resemble those of acute perforated peptic ulcer At operation the condition is recognised by the presence in the peritoneal cavity of intestinal gas foul-smelling pus and even fæces *All peritoneal exudate and foreign matter must be evacuated* by suction and swabbing and wide drainage of the lower abdomen and pelvis established If possible the affected segment of bowel should be brought to the surface as a colostomy Failing that an attempt is made to close the perforation (difficult owing to its size and the surrounding induration) or to occlude it by omentum. The prognosis is very grave

Perforation of a diverticulum into the extraperitoneal tissues or into a peritoneal pocket surrounded by adhesions leads to the formation

of an abscess and is treated by simple incision and drainage Often the abscess is heavily infected by *B coli* and anaerobes and healing is slow

Obstruction due to inflammatory fibrosis is rare and must be diagnosed from malignant disease Sometimes if the disease is localised and not unduly fixed the affected segment may be removed by the Paul Mikulicz method More commonly resection is not feasible and in such cases colostomy should be performed at a higher level This by putting the affected segment at rest may permit the inflammation to subside with relief of the obstruction and later (sometimes after several months or years) the colostomy may be closed

Fistula between the colon and the bladder is a sequel to infection and ulceration of a diverticulum and the communicating channel is buried in a dense inflammatory mass, usually low in the pelvis Attempts to define and close the fistula under these circumstances are doomed to failure Accordingly the proper treatment is to establish a colostomy generally in the transverse colon. Subsequently when the infection has subsided repair of the fistula is occasionally practicable

MALIGNANT DISEASE OF THE COLON

The problems that arise in relation to operations on the colon are very different from those which confront the surgeon when he operates on the small intestine The colon has a relatively poor blood supply and its contents are solid or semi-solid and highly infective The risks of operation due to infectivity of the colon have been materially lessened by the introduction of sulphathalidine and streptomycin which either alone or in combination have a profound effect on the bacterial flora of the colon Sulphathalidine is given orally for from five to seven days pre-operatively Streptomycin is also given orally and usually a two-day course suffices Except in its transverse and sigmoid portions the colon has an incomplete peritoneal coat and its fixity renders free mobilisation an essential step in any resection and anastomosis In addition the presence of three lines of tension the *Tænia coli* gives rise to difficulties when an end to-end union is desired, and post-operative flatulent distension throws a serious strain on lines of suture Apart from these local difficulties treatment is complicated by the fact that malignant disease of the colon tends to occur in middle aged or elderly persons who from colon stasis secondary anæmia and general deterioration are frequently poor surgical risks Finally there is the complication of acute intestinal obstruction in the distal colon the malignant stricture is insidious in onset and many patients seek aid only when acute or subacute obstruction is already established.

Once the diagnosis of cancer of the colon has been made two questions arise —First Is the growth removable? Secondly By what surgical procedure can this best be achieved? These questions can be answered with certainty only after the abdomen has been opened Opinions differ widely as to what constitutes an operable cancer In the hands of a bold and experienced surgeon many tumours which at first appear to be irremovable can be successfully eradicated

In young persons cancer usually grows with great rapidity and radical excision though possible is rarely curative In the very old operation should be avoided except to relieve obstruction Speaking generally it may be said that in the majority of cases the patient should be given the chance which only a successful operation can offer Wide spread metastases will preclude radical excision but local invasion of the stomach adjacent small bowel, or the abdominal wall is not necessarily a reason for abandoning the operation Local fixation of the affected colon may appear to rule out the possibility of resection, but in many cases this fixation is the result of secondary inflammatory changes rather than of malignant invasion and need not be a contraindication to operation

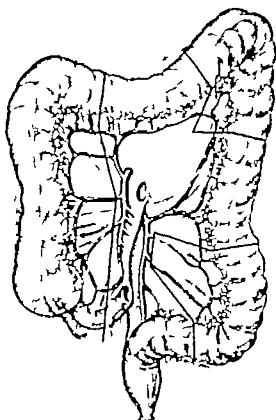


FIG 298

Resection of colon. The dark lines indicate the extent of the resection carried out for growths in the proximal colon, at the splenic flexure and in the sigmoid loop.

Choice of operation —The treatment of cases with acute obstruction due to carcinoma of the colon has already been considered (p 598) In cases without gross obstructive symptoms the choice lies between primary resection with an immediate anastomosis and some form of stage operation Primary resection has the advantage that the patient is subjected to only one operation but is not without danger for it throws a severe strain on a patient who may be debilitated and whose peritoneal cavity has not developed that powerful immunity which a previous laparotomy provides This danger has, however been greatly reduced by modern methods of pre-operative preparation using sulphathalidine and streptomycin. Whether the operation be done in one or more stages to fulfil its object it must entail the removal of a freely mobilised segment of bowel together with its mesentery and associated lymphatics

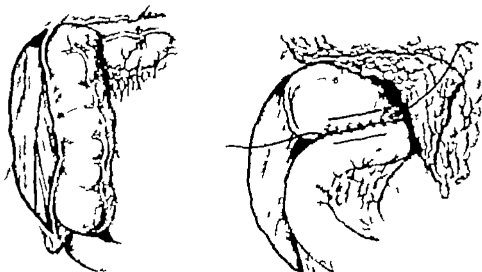
In carcinoma of the proximal colon whatever the precise position of the growth a standard resection is performed which involves excision of the terminal 6 in. of the ileum the cæcum and ascending colon and the proximal third of the transverse colon This wide resection is necessary since adequate removal of the regional lymph nodes involves division of the ileocolic and right colic vessels and thus cuts off the blood supply to the whole part In the majority of cases this operation can be done in one stage but if the patient is in

poor condition or if obstructive symptoms be present a preliminary ileotransverse colostomy is performed and the excision carried out a fortnight or so later

In the left half of the colon the risks of primary resection and anastomosis are undoubtedly greater than on the right side for the bowel contents are solid and some degree of obstruction is usually present It is in such circumstances that an operation in stages is most valuable

Resection of the Proximal Colon

A right paramedian incision is usually employed but better access is obtained by opening the abdomen more laterally This entails division of the oblique muscles but in the absence of infection a strong abdominal scar can be expected. The small intestines are



(1) (2)

Fig 200

Resection of the proximal colon. (1) Division of peritoneum preparatory to mobilising the affected segment (2) The segment has been removed and the two blind ends inverted. Lateral anastomosis is being performed between the ileum and the transverse colon.

excluded from the operative field by packs assisted by slight lateral tilting of the table The cæcum and ascending colon are then mobilised by incising the peritoneum in the paracolic gutter an almost avascular layer and the whole segment is stripped with its associated fat and lymphatics towards the middle line The spermatic vessels and ureter are avoided and as the right colic flexure is mobilised the retroperitoneal portion of the duodenum comes into view and must be protected from damage The medial stripping of the colon is continued almost up to the superior mesenteric vessels The whole of the proximal colon is now freed and can be brought outside the abdomen The vessels supplying the segment to be resected—terminal branches of the ileal vessels the ileocolic and right colic vessels and marginal vessels to the right-hand part of the transverse colon—are now ligated.

This step is facilitated by illuminating the mobilised mesocolon It is now necessary to divide the transverse colon and the ileum and anastomose them The transverse colon in its proximal third is first cleared by stripping the omentum from it and at the site selected the seromuscular coat is divided all around leaving a tube of submucous and mucous coats This narrow tube is ligated and the bowel divided between the ligature and a clamp applied more proximally The resulting stump is invaginated and secured by a purse-string suture of linen thread

The procedure to be adopted with the divided ileum depends upon whether the anastomosis is to be an end to-side or a lateral ileo-transverse colostomy If as is preferable a lateral anastomosis is employed the ileum is divided in the same way as the colon and its end invaginated A lateral anastomosis is then made between ileum and colon as described on p 602 Finally the raw area on the posterior abdominal wall is covered by suturing the divided edges of the peritoneum to prevent adhesion of small intestine which might later lead to obstruction.

This operation is necessarily a formidable procedure but with adequate preparation gentle intra-abdominal manipulations and a post-operative blood transfusion operative shock can be reduced to a minimum The complication most to be feared is leakage at the suture line with peritonitis It is most likely to occur about a week after operation Apart from gross interference with the blood supply at the site of anastomosis leakage is usually due to tension which of itself tends to interfere with the vascularity of the part Adequate mobilisation is therefore essential and distension by gaseous fermentation must be avoided

Colostomy

Colostomy is indicated as a temporary measure to divert the faecal content in diverticulitis or in chronic rectal and anal suppuration as a preliminary to resection of the distal bowel and as a palliative in inoperable malignant disease

Inguinal colostomy—in which the pelvic colon is brought to the surface—is the operation of choice for permanent drainage and is generally used also as a preliminary to removal of the rectum Transverse colostomy is less suitable for permanent drainage as the bowel content is semisolid and more difficult to control but it may be required for inoperable carcinoma of the splenic flexure or descending colon It is more valuable as a temporary measure for the relief of obstruction of the distal colon and as a preliminary to resection of the distal colon

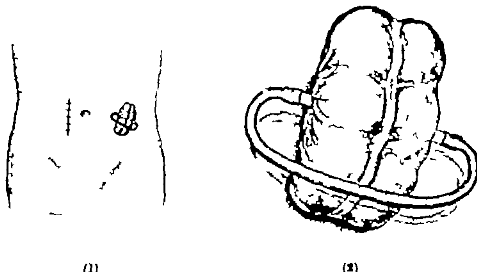
Inguinal Colostomy—The incision is made in the left lower quadrant It may be of grid iron type or may split the rectus muscle and should be no longer than is necessary to deliver the colon If wide exploration is needed, a midline or paramedian incision should be made first and the colostomy then established through a stab wound

If the colon is freely mobile it can be delivered without difficulty if not it is mobilised by incising the peritoneum on the lateral side of its mesentery and stripping the bowel medially If the colostomy

is performed as a preliminary to excision of the rectum, the upper part of the pelvic colon should be chosen for the drainage In other circumstances the part most readily delivered is chosen

A glass rod is introduced through a bloodless area of the mesocolon to prevent retraction of the colon and is itself held in place by a short length of rubber tubing which is slipped over its ends (Fig 300) The mesocolon may be fixed to the parietal peritoneum by a few sutures No stitches should be inserted into the wall of the gut lest they tear through and permit infection of the wound Finally the bowel is covered with a sheet of perforated green protective to prevent the dressings from becoming adherent

In the presence of obstruction the colostomy must be opened at once A purse-string suture of strong silk is introduced, the bowel



(1) (2)

FIG. 300

Left inguinal colostomy (1) The abdomen has been explored through a right paramedian incision. The sigmoid loop has been brought out through a small counter incision on the left side. (2) Note the glass rod passed through the mesocolon and held secure by a loop of rubber tubing

is opened, a Paul s tube inserted and tied in position If there is no urgency opening of the bowel should be postponed for five or six days Any early painful distension can be relieved by puncturing the bowel with a cautery and inserting a small catheter The final opening is made in the transverse axis of the bowel with a cautery or knife but must not be carried down to the rod for at least ten to twelve days lest the bowel retract and the colostomy be narrowed or closed

Transverse Colostomy—The abdomen is opened by an incision through the upper part of the left rectus The transverse colon is identified and the omentum stripped from that portion of the bowel which has been chosen for the colostomy The loop is fixed outside the abdomen as in an inguinal colostomy If as will usually be the case the colostomy is to be a temporary one its later closure will be facilitated if the bowel proximal and distal to the colostomy is secured by interrupted serous sutures to form a spur as is done in a stage resection (p 619) When the operation is performed as a

preliminary to resection of the distal colon or rectum Devine s method may be used, in which the colon is divided completely across and the ends brought to the surface in such a way that the openings are separated by a bridge of skin This ensures that no fæcal material can find its way into the distal bowel which may thus be cleansed and rendered well nigh aseptic

After-care of Colostomy Cases.—If properly cared for a colostomy should cause but little inconvenience and should not debar the patient from ordinary social activities

Whatever technique is used no sphincteric control can be provided for the artificial anus Consequently either diarrhœa or constipation (with retention of fæces in the bowel immediately proximal to the orifice) will lead to continual soiling The aim must therefore be to secure evacuation of the whole colon regularly once or twice daily and if this is achieved little or no soiling should take place at other times The regular evacuation should be secured by careful attention to the diet which must be adjusted to suit individual needs and the aim should be to avoid all aperients Liquid paraffin in particular should be prohibited for it tends to promote a continuous ooze of oily fæces In some cases if such a routine is established when the toilet has been made after each evacuation it is only necessary to cover the colostomy with a thin layer of wool, supported by a corset or body belt Most patients however prefer to wear a colostomy cup as an additional precaution

If despite all care it is found impossible to secure regular evacuations a constipating diet should be advised and the patient should be instructed to empty the bowel regularly by a soap-and water enema introduced into the proximal limb of the colostomy by means of a tube and funnel

Cæcostomy—This operation is unsatisfactory as a permanent method of drainage since the contents of the proximal colon are fluid and excoriate the surrounding skin. It is valuable however as a temporary measure either as a safety valve to prevent distension after primary resection with anastomosis of the distal colon, or as an emergency measure for the relief of acute obstruction of the colon In this latter condition the drainage may be carried out after exploring the abdomen and locating the growth but in advanced cases in which the site of the obstruction is not known and the colon is greatly distended a blind cæcostomy is often preferable for thus the obstruction can be relieved without the difficulty and danger associated with wide exploration It must be recognised however that cæcostomy does not provide very efficient drainage and fails to divert the whole fæcal current from the distal colon For these reasons if the obstruction is known to be in the distal colon a transverse colostomy is generally preferable.

The abdomen is opened by a grid iron incision and the cæcum exposed On no account must the whole cæcum be brought outside the abdomen as the distension of the bowel may be so great that the peritoneal coat tears and its wall may rupture When possible a portion of the cæcum is delivered into the wound emptied by compression and a light clamp applied The wound is protected by moist

packs and a purse-string suture inserted Within this suture a small opening is made and a wide-bore rubber tube or Pezzer catheter with its projecting tip removed is inserted and the suture tied Further sutures are introduced as in a Senn's gastrostomy and this is rendered easier if the clamp is released to permit escape of flatus and fæces by the tube The cæcostomy should be retained until the obstructing lesion has been resected or, if that proves to be impossible until a more suitable form of colostomy can be established. In most cases the cæcostomy opening closes spontaneously once the tube is removed.

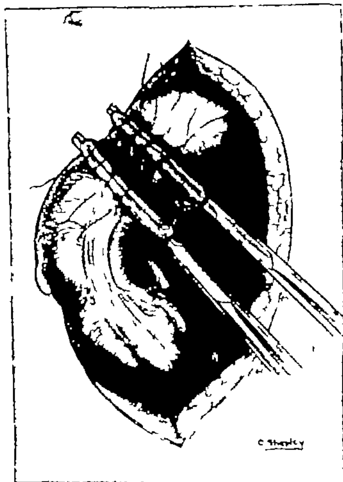


Fig 301

Aseptic anastomosis by one row of interrupted linen sutures. Posterior row inserted and tied anterior row being inserted. (*By courtesy of the "Edinburgh Medical Journal."*)

Resection of the Distal Colon

Since carcinoma in the distal colon generally grows slowly and involves but few glands a limited resection usually suffices, including a few inches of bowel to either side of the growth along with a fan-shaped portion of the mesocolon

Two types of operation are in use The one is to resect the affected segment and restore continuity by end to-end anastomosis This method is not free from danger owing to the risk of peritonitis from leakage *at the suture line* and should be performed only by expert surgeons in specially suitable cases for example in cases where a colostomy performed previously to relieve obstruction has given the opportunity to cleanse the bowel thoroughly

The second type of operation is the Paul Mikulicz multi-stage procedure in which the segment of colon is brought out at the wound and later divided at the skin level forming a colostomy which can later be closed. This method carries a lower mortality and is equally effective in eradicating the disease but involves *greater discomfort* and a longer period of treatment

Resection and Anastomosis.—If the growth is in a fixed portion of the colon the affected segment must first be mobilised. This is

readily done by dividing the peritoneal reflection lateral to the colon and stripping the colon medially and forwards off the posterior parietes In this way the splenic flexure or descending colon can be freed sufficiently to be brought out at the wound In the case of the transverse colon mobilisation is effected by dividing the gastro-colic ligament and separating that part of the greater omentum which is attached to the diseased segment from adjoining portions

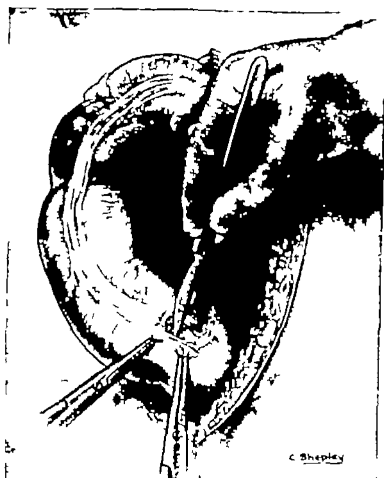


FIG 297

Division of taenia of colon. The first step in all colon resections.
(*By courtesy of the "Edinburgh Medical Journal."*)

The next step is to outline a fan-shaped portion of the mesocolon of the affected segment planned so as to include any enlarged glands but to preserve the blood supply to those parts of the colon that are not to be removed (Fig 298)

At the sites selected for division of the bowel a cuff of the seromuscular coats is raised leaving the submucous and mucous coats intact Narrow bladed powerful clamps are applied side by side and the mucosal tube divided between them The affected segment together with its mesocolon can now be removed.

End to-end anastomosis is preferably carried out by a single layer of interrupted linen or silk sutures applied while the clamps are in position With the clamps rotated outwards the posterior

seromuscular coats are united by interrupted linen sutures which are tied and cut short The clamps are then rotated inwards and similar sutures inserted into the anterior seromuscular layers but are not immediately tied When the last suture has been placed in position the clamps are released and gently withdrawn, and the sutures are then tied The surfaces of the crushed mucosal tube remain gummed together during this process consequently little or no contamination can occur

To prevent distension of the colon in the post-operative phase a temporary *cæcostomy should* be *established* before the wound is closed except in those cases where there is already a colostomy

Paul Mikulicz Method —Here the first steps again are to mobilise the affected segment and outline a fan shaped portion of the meso colon The loop is now brought out at the wound The gap in the mesocolon is closed by a few sutures and the afferent and efferent portions of gut are apposed by further sutures uniting the seromuscular coats. The wound is now closed layer by layer round the base of the exteriorised loop When the skin stitches have been inserted heavy crushing clamps are applied to the two ends of the loop flush with the skin The bowel is then divided preferably by cautery and the segment removed leaving the emerging ends of the colon controlled by the clamps

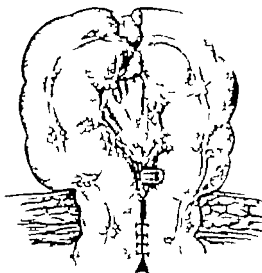


Fig 303

Paul Mikulicz resection of the colon. The affected loop has been mobilised, its mesocolon divided, and the two limbs sutured together

The clamps are left in position for two days, or longer if there is no marked abdominal distension or discomfort The proximal clamp is then removed and an angled glass colostomy tube inserted in the open end of the bowel The distal clamp may be left in position until it sloughs off usually on the fifth or sixth day

Two weeks or so later when the general health is restored, the next stage is carried out It consists in applying an enterotribe a two bladed crushing instrument to the spur between the two bowel openings. *This step requires no anæsthesia* The enterotribe is gradually tightened until the tissue in its grip necroses and sloughs away The bowel contents now tend to by pass the colostomy and the external orifice gradually narrows

A final stage is generally required to effect complete closure of the colostomy Often it can conveniently be postponed for several weeks and during this period the patient may return home

K P B

ULCERATIVE COLITIS

Ulcerative colitis may develop acutely and pursue a fulminant course with severe toxæmia and an early fatal issue In such cases surgical treatment offers little prospect of alleviation and carries a prohibitive mortality More often however it progresses less actively with a chronic course characterised by remissions and exacerbations In such circumstances surgical treatment often is most effective while owing to advances in preliminary care and technique the risks of operation have been greatly reduced

Operation is indicated in intractible cases with severe diarrhœa in cases with recurrent severe hæmorrhage and in cases complicated by stricture polyposis abscess or fistula formation



FIG 204
Ileostomy for ulcerative colitis. 1 The incision.

In nearly all cases it is necessary to establish a permanent ileostomy to be followed when the general condition is sufficiently improved, by resection of the whole colon and perhaps also the rectum. The ileostomy is made in such a way as to allow of the use of a special bag designed to prevent the constant soiling and skin excoriation which formerly were the inevitable effects of this operation In rare cases where the disease is limited to the distal part of the colon a colostomy at or near the hepatic flexure may be performed.

Pre-operative Preparation —Patients with ulcerative colitis are nearly always in poor general condition and require prolonged preparation The local lesion in the bowel is accompanied by severe nutritional deficiencies anæmia sepsis and toxæmia all of which require correction

Often there is a severe degree of hypoproteinæmia due to impaired absorption and excessive loss from the bowel. Such patients should be put on a high protein diet supplemented by concentrates to give a daily intake of 200 to 300 g If the appetite is poor a continuous milk drip may be given by nasal catheter with the addition of casein hydrolysate while in severe cases hydrolysate may be given intravenously

Anæmia is a constant finding in severe cases due to the toxæmia and to repeated loss of blood in the stools Some improvement may be gained by the administration of iron and the use of liver has also been advised. The greatest benefit however is obtained by blood transfusion and in severe cases as much as 6 pints may be given spread over the period of two or three weeks

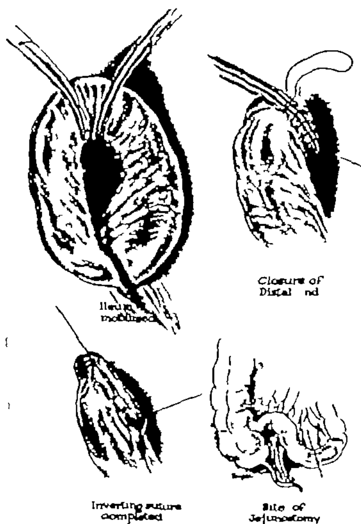


FIG. 305

Ileostomy for ulcerative colitis. 2. Ileum divided and distal end closed.

Vitamin deficiencies are also common A deficiency of vitamin B may lead to mental depression and dermatosis while lack of vitamin K may impair the prothrombin synthesis and aggravate the bleeding tendency Both these vitamins and also vitamin C should be administered in adequate doses.

Control of the heavy infection from the diseased colon is important not only to improve the general condition but also to diminish the risks of operation For this purpose sulphathalidine is given for a week before operation supplemented by parenteral penicillin and ora

streptomycin during the two days immediately before operation. Penicillin and streptomycin may be continued post-operatively

Technique of Ileostomy for Ulcerative Colitis.—The abdomen is opened through a right rectus incision The terminal ileum is identified and divided at a point 5 in from the cæcum The distal end may be closed and inverted or as is preferable it may be brought out at the wound.

The proximal end of ileum is now mobilised by dividing its mesentery for some 6 in proximally In dividing the mesentery the line of incision

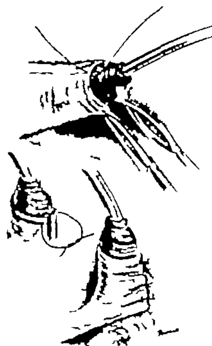
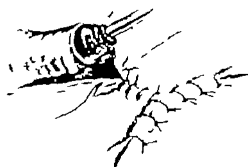


FIG 306
Ileostomy for ulcerative colitis.
3 Stump of ileum brought to surface and covered by skin flaps.

should be made a full inch away from the bowel in order to preserve the distal arcade This 6 in length of distal ileum is now brought out through a stab wound in the right iliac fossa and made to project beyond the skin surface in the form of a spout Its base is fixed to the parietal peritoneum by several interrupted sutures The projecting spout of ileum may be covered by a free split skin graft obtained from the thigh. Alternatively the incision shown in Figure 307 may be used so as to fashion a pedicle graft from the abdominal skin. To prevent contamination a large size self retaining catheter is introduced into the lumen and fixed in place with a purse string stitch.

Post-operative Care.—The ileal catheter can be expected to stay in position for two or three days When it becomes loose great care must be taken of the skin to prevent excoriation A paste containing 10 per cent of metallic aluminium is satisfactory for this purpose

A special rubber bag should be in readiness and this is fitted over the ileostomy to collect the greater part of the drainage In the course of two or three months the ileostomy shrinks and assumes its permanent size A specially fitted bag can then be worn strapped to the abdomen and thigh In this way the patient is enabled to lead a fairly normal life At first the intestinal content is fluid and discharges continuously but later it tends to become solid and more intermittent



Suture of Skin



Closure completed

Fig 307

Ileostomy for ulcerative colitis. 4. Skin suture completed.

Colectomy for Ulcerative Colitis.—When the ileostomy has been established the colon infection diminishes and in the course of time the discharge of blood and mucus from the anus is reduced to very small proportions Formerly it was recommended that at this stage the ileum should be re-implanted into the colon or into the rectum but this almost invariably re-activates the disease and it is now thought preferable to retain the ileostomy as a permanency and also to excise the diseased colon The *colectomy* may be carried out in two or three stages If the patient is in sufficiently good condition the proximal

colon may be removed at the time of the initial ileostomy More often this stage must be carried out at a separate session Subsequently the distal colon down to the sigmoid loop is removed at a further stage and in some cases subsequently the rectum may require to be excised. In favourable cases the distal colon and rectum may be removed together

C F W I.

REFERENCES

BEST R. R. (1948). "Operative Procedures in Carcinoma of the Colon. *Surg Gynec. Obstet.*, **86**, 98.

BRUUSGAARD C. (1947). "The Treatment of Volvulus of the Sigmoid Colon. *Surgery* **22**, 466

HARDY T L. BROOKE, B. N and HAWKINS, C F (1949). "Ulcerative Colitis." *Lancet* **2**, 5.

HOXWORTH I L., and MITHOEFER, J (1947). "The Management of Carcinoma of the Colon. *Surgery* **22**, 271

M KITTRICK, L. S. (1948). "Principles of Resection of the Colon for Carcinoma. *Surg. Gynec Obstet* **87** 15.

MILLER, G G RIFSTEIN C. B. and TABAH E. J (1949). "Surgical Management of Ulcerative Colitis. *Surg Gynec. Obstet* **88**, 351

SMITH, R. (1948). "Gastro-Intestinal Decompression in the Treatment of Acute Obstructions. *Annals of Royal College of Surgeons of England.*, **2**, 34.

CHAPTER XXXIV

AFFECTIONS OF THE RECTUM AND ANUS

ANATOMY

THE anal canal extends from the level of the levatores ani to the anus a distance of 1 to 1½ in

The mucous membrane presents five to ten vertical folds separated by grooves known as the anal columns Each column is formed by an infolding of the mucous membrane and contains an internal hæmorrhoid.

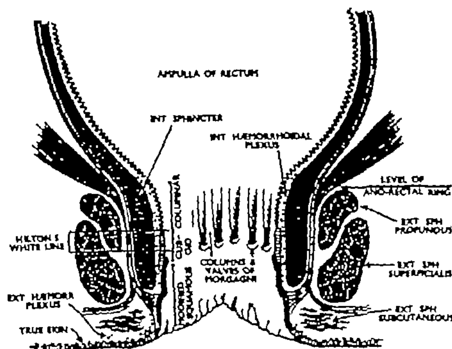


FIG. 306
Detailed anatomy of the anal canal.

At the lower end of each groove is a small fold of mucous membrane—an anal valve—and it is here that infection is liable to gain entry as a result of a tear of the valve by a scybalous mass Crossing the lower end of each column and passing through each valve runs the line of junction between the squamous epithelium derived from the anal pit below and the columnar epithelium derived from the hind-gut above This is called Hilton's White Line The mucous membrane is sensitive below this line and insensitive above

The *rectum commences* at the level of the third sacral vertebra and ends at the level of the levatores ani Its length is 5 to 6 in. Within the lumen there are folds of mucous membrane two on the left and one on the right side—the valves of Houston

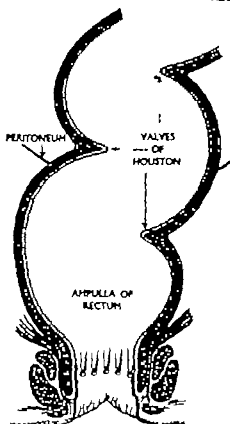


FIG. 300
Anatomy of the rectum to show the valves of Houston and the relation of the peritoneum.

The posterior surface of the rectum is devoid of peritoneum but at the sides and in front peritoneum is present Anteriorly the peritoneum leaves the rectum to form the floor of the recto vesical or the recto-uterine pouch at a point 3 in above the anus In the male the peritoneal reflexion is 1 in above the prostate That part of the rectum which has no covering of peritoneum is the most distensible part and is called the ampulla and is the site of many tumours of the rectum

The point of junction of the rectum with the pelvic colon is the narrowest part of the lumen and is the site of development of the ' pelvi rectal ' carcinoma

The lymph drainage of the rectum is upwards to the glands lying deep to the fascia propria and so to the glands lying along the superior rectal artery

The lymphatics of the anal canal drain to the inguinal glands

HÆMORRHOIDS

The common predisposing factor in hæmorrhoids is constipation with fæcal stasis in the rectum Effective treatment of the constipation will cure many cases of early hæmorrhoids and give relief even in late cases

If such conservative measures fail, the choice of treatment lies between injection and operation *Injection is most satisfactory* where there is a single small hæmorrhoid which bleeds during defæcation but causes no other symptoms it is also to be preferred where there are small hæmorrhoids which prolapse during defæcation but return spontaneously

Injection treatment is not suitable where the hæmorrhoids are large and remain prolapsed it is contraindicated for external hæmorrhoids and after an ' acute attack of piles '

Injection Treatment —The patient requires no special preparation and can be treated as an outpatient The injections are carried out at weekly intervals. The patient is warned to keep the bowels moving freely by the taking of liquid paraffin (½ oz two or three times a day)

He is particularly warned that if the piles prolapse after injection they must be replaced immediately

The male patient kneels on the operating table with his shoulders low and his back hollowed The female patient lies on her left side. A proctoscope is passed into the rectum, its obturator is removed, and it is then withdrawn a little until the anal canal is seen beginning to close over the end of the instrument Here the internal hæmorrhoids will be seen as dilated veins The injection fluid—3 c c of 5 per cent phenol in almond oil—may be injected into the centre of the pile itself in order to thrombose it or into the submucous coat of the rectum a little farther up with the object of both thrombosing the vein and producing fibrosis which by its contraction, will draw up the mucous membrane Care must be taken that the injection is made deep to the mucosa lest necrosis take place



FIG 310
Internal hæmorrhoids. The alternative sites for injection are indicated.

Operative Treatment —The procedure now usually adopted is the Dissection and Ligature operation in which the main piles along with the overlying strips of mucous membrane are dissected upwards ligated and removed

To prevent fæcal contamination during operation an aperient should be given two days earlier and an enema on the evening before operation A simple wash-out of the colon is given on the morning of operation.

Inhalation anæsthesia is customary or spinal anæsthesia may be used The patient is placed in the lithotomy position the part is cleansed, and the anal canal inspected.

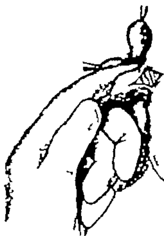


FIG 311
Dissection and ligature operation for hæmorrhoids. The index finger is inserted into the anal canal. Three pile masses are held in forceps. The right-hand pile is being dissected off the external sphincter preparatory to ligation of its base.

Generally there are three main pile masses one anterior the others posterolateral Each in turn is picked up by tissue forceps and the incision is made enclosing a small triangular area of skin close to the anal margin and a longer triangular-shaped area of the mucosa covering the hæmorrhoid The pile is carefully dissected off the sphincter transfixed and ligated at its upper end with a catgut stitch, and cut short It is important to see that the catgut stitch does not include the sphincter as this is a frequent cause of pain after the operation.

The ligated end of the pile may be allowed to slip up or the ends of the ligature may be used to stitch it to the skin margin After each pile has been dealt with in this way, care being taken that a strip of healthy mucosa remains between the piles any small external hæmorrhoids are snipped off and a vaseline dressing applied. The post-operative care is simple A fluid diet is given for four days to delay action of the bowels An aperient is then given followed by an olive-oil enema to ease the strain of defæcation Liquid paraffin may be prescribed from the second day with the same object

Acute Attack of Piles.—An acute attack of piles occurs when the hæmorrhoids prolapse and become gripped by the external sphincter The veins of the prolapsed mass are engorged and soon thrombose later ulceration of the mucous membrane occurs If the condition is seen soon after its onset before thrombosis has occurred it may be possible to reduce the prolapsed mass digitally when immediate relief is obtained If this is not possible usually because thrombosis has

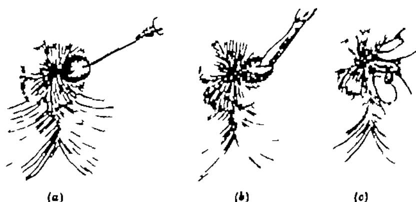


Fig 312

The method of treating a thrombosed external pile. (a) The injection of the local anæsthetic. (b) The incision. (c) The release of the clot.

occurred the patient is confined to bed with the foot of the bed raised given liquid paraffin and kept on a low residue diet After a week the mass will become reduced in size and eventually will retract Operation is generally advisable later although in a proportion of cases a 'spontaneous cure with relief of symptoms occurs as a result of the thrombosis of the veins

External Hæmorrhoids—These only rarely give rise to symptoms except when thrombosed If they should become inflamed or ulcerated they may be snipped off using a local anæsthetic

Thrombosed External Pile—During straining at stool or in the passage of hard fæces a peri anal vein ruptures and a hæmatoma forms below the skin The patient experiences a sharp pain and a swelling appears. On examination a small, soft, rounded swelling, bluish in colour is seen near the anus After a few days the clot begins to organise and the swelling becomes firm The pile may cause severe pain and require immediate treatment which can easily be carried out Under local anæsthesia a short incision radial to the anus is made in the thin skin over the swelling The incision is deepened and the clot turned out A small wick of vaseline gauze is then inserted

and the wound is left to granulate The pain is relieved immediately, no confinement to bed is necessary and the wound heals completely within a week or two

ANAL FISSURE

A fissure is caused by tearing or stretching of the anal mucosa by the passage of hard scybala, and is maintained by constipation and spasm of the anal sphincters

A superficial fissure of recent origin heals readily if constipation is treated by the regular use of laxatives and hard scybala prevented by the use of liquid paraffin An ointment may be applied locally

In deeper fissures of long standing spasm of the sphincter should be overcome by means of a local anæsthetic such as proctocaine 2 c c of which may be injected into the sphincter immediately deep to the fissure

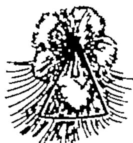


Fig 313
Fissure with sentinel pile. Area of excision.

If these methods fail and especially if there is much induration round the fissure, under general anæsthesia the sphincter should be thoroughly stretched sufficiently to admit three fingers and thereafter the fissure and surrounding area of induration should be excised the resulting raw area being left unsutured The after-care is the same as for hæmorrhoids.

PROLAPSE OF THE RECTUM

Prolapse of the rectum occurs most often in children and elderly persons and the treatment differs in these two classes The prolapse is generally attributable to laxity of the sphincters and perineal supporting tissues—the result of malnutrition or wasting—and to excessive straining brought about by constipation, worms difficulty in micturition, and similar factors In the treatment any such predisposing cause must receive due attention.

Treatment in the Child —The prolapse is reduced by holding the child up by the heels and applying gentle pressure to the mass Reduction usually takes place easily Recurrence is prevented by applying a pad over the anus and strapping the buttocks together with adhesive strips The bowels must be regulated and during defæcation the nurse should exert lateral pressure on the buttocks to prevent extrusion. By such means and by attention to the general nutrition a cure can generally be expected in a few weeks If not 5 per cent phenol in almond oil should be injected into the submucous coat of the rectum to induce fibrosis General anæsthesia is required Five or six injections each of 2 c c are made at various points round the rectum as high as possible

Treatment in the Adult —The prolapse is reduced by applying gentle pressure to the mass Recurrence is prevented by elevating the foot of the bed and by regulating the bowels to prevent straining Except in the mildest cases operation is required to obtain permanent cure

Where the prolapse is slight and hæmorrhoids are present the operation is similar to that recommended for hæmorrhoids and as an additional measure a tuck may be taken in the external sphincter either anteriorly or posteriorly

In more severe cases the *most satisfactory method is to perform* recto-sigmoidectomy

With the aid of penicillin and the sulphonamides removal of the prolapsing mass is now a safe procedure The prolapsed part is drawn down as far as possible The mucous membrane is incised about an inch above the anus and this incision is deepened through the whole *thickness of the bowel wall* The *peritoneal cavity is opened and the* proximal end of the bowel is drawn down as far as possible It is divided across as high as possible Numerous vessels require to be ligated An end to-end suture is carried out between the upper end *of the divided bowel and the short portion lying above the sphincters.* The peritoneal cavity is closed at this stage If the bowel has been well pulled down before the resection is performed, *it will be found* that the upper end will be drawn up after the anastomosis has been completed and the prolapse will so be cured. A full course of penicillin and sulphonamides is given to prevent the development of peritonitis and to allow the anastomosis to heal without infection

ISCHIORECTAL ABSCESS

This condition occurs as the result of infection gaining entry into the fat of the ischiorectal fossa through a small crack in the mucosa of the anal canal

At first there is a throbbing pain, which later becomes intense On examination a hot red, and tender swelling will be seen to one or other side of the anus

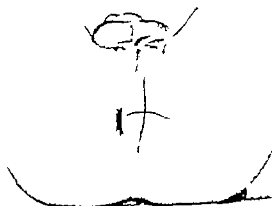


FIG 314
Incision for acute ischiorectal abscess.

The abscess should be incised as soon as it has been *diagnosed for* the fat has a poor resistance to infection and the infection may spread even to the fossa on the opposite side or *the abscess may rupture* into the anal canal with the formation of an internal sinus. Care must be taken that the incision is sufficiently large to give adequate *drainage for it must be remembered that* as the swelling subsides the incision will contract The most satisfactory method is to make a cruciate incision, one limb radiating from the anus the other—3 or 4 in long—at right angles to this The incision

should be so large as to obviate the necessity for packing it open The points of the four flaps should be snipped off, as they are apt to slough

Pelvirectal Abscess.—This results from infection of the pelvic cellular tissue above the levator ani

The abscess usually bursts spontaneously into the rectum or may be opened by this route Rarely it may burst into one of the ischiorectal fossæ and give rise to an ischiorectal abscess, which is dealt with in the way already described

ANAL FISTULÆ

External Sinus in Ano—This results from an acute ischiorectal abscess which has been inadequately opened or has ruptured spontaneously There is a chronic abscess cavity in the ischiorectal fossa, from which a track lined by granulation tissue passes to the skin surface The opening of the track is usually found about an inch from the anal margin and a little pus may be seen exuding from it From time to time the abscess cavity fills up becomes inflamed and then discharges through the opening It may have ramifications passing in many directions through the ischiorectal fossa and even to the fossa on the opposite side

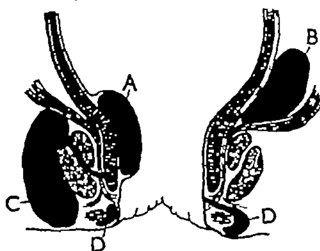


FIG 313

Diagram of anal canal showing —
(a) Sub-mucous abscess.
(b) Pelvirectal abscess.
(c) Ischiorectal abscess.
(d) Peri-anal abscess.

The secret of treatment is to lay the track and the abscess cavity widely open A probe is passed into the sinus and a careful exploration made Under general anæsthesia with the patient in the lithotomy position, the track and all the ramifications of the abscess cavity are laid wide open. If there is much induration around the track it should be excised. Any such tissue should be examined microscopically for tuberculosis, which is commonly responsible in the more chronic cases

Finally the wound is lightly packed with gauze wrung out of eusol or flavine 1 1 000 solution

In the after treatment, packing of the wound is continued so that healing takes place by granulation from the base upwards It is wise to keep the patient in bed until healing is well advanced otherwise the sinus may persist

Internal Sinus in Ano—This rare condition results from an acute ischiorectal abscess which has burst into the anal canal. The patient

complains of attacks of pain in the anal region and of a purulent discharge from the anus

The opening of the sinus is usually between the internal and external sphincters in the midline either anteriorly or more commonly posteriorly

Rarely such a case may be due to infection which has originated in

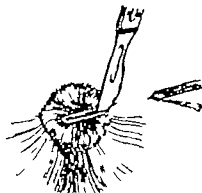


Fig 316
Laying open the fistula by cutting down on to a dissector

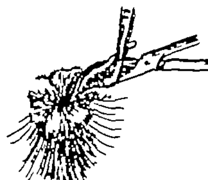


Fig 317
The excision of the track of the fistula

the pelvis and has pointed under the mucous membrane of the anal canal or rectum X ray examination of the pelvis after the track has been injected with lipiodol will show the origin of such a sinus Its treatment will depend upon the primary cause in the pelvis

The treatment is similar to that for complete fistula in ano

Fistula in Ano —In this condition there is a track lined by granulation tissue leading from the anal canal to the skin surface The

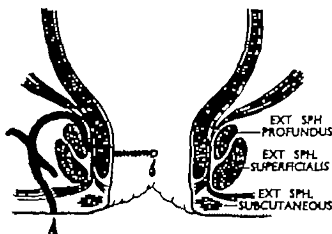


Fig 318
Complete fistula, showing subsidiary tracks branching from the main track, all of which must be laid open.

external opening lies usually about an inch lateral to the anus while the internal opening usually lies between the internal and external sphincters in the midline in front or behind Even if the internal opening lies at a higher level it is usually found that the deep part of the track is submucous and therefore does not pass deep to the internal

sphincter, which is thus not endangered by the operation The fistula fails to heal spontaneously owing to the constant movement of the sphincters and the frequent reinfection from fæces

Under general anæsthesia, with the patient in the lithotomy position a probe is passed along the fistula and through the internal opening into the anal canal and is then hooked out of the anus An incision is made on to the probe which is thus freed and lifted out of the wound If the tissue round the fistula is tough and fibrous it should be excised until healthy tissue is reached All ramifications of the fistula must then be followed and either laid widely open or preferably, excised Finally the whole wound is packed so that it may granulate from the base up The excised tissue should be examined microscopically for tuberculosis, which is commonly responsible

In the rare cases in which the track passes deep to the internal sphincter a two-stage operation is carried out At the first stage the upper part of the track is exposed through a proctoscope and laid open Later when this part of the track is healed, the remainder is treated as described above

In very extensive recurrent fistulæ a temporary colostomy should be performed to divert the fæcal matter and put the part at rest until healing is complete

PRURITUS ANI

This troublesome condition of irritability in the region of the anus is difficult to treat. Usually the skin shows reddening and thickening with small cracks in the thickened epithelium

Frequently the pruritus is secondary to other lesions of the rectum and anus such as hæmorrhoids fissure fistula or proctitis It may also occur in diabetic patients When these conditions are treated the pruritus clears up

Strict personal hygiene is essential, the part being washed over with soap and water after the bowels move It is important that the soap be washed off completely A local anæsthetic ointment is then applied. If this treatment fails, and the area affected is fairly well localised the injection of a local anæsthetic with a prolonged action (such as proctocaine) may give relief X ray therapy is sometimes effective

If all other methods have failed, Ball's operation may be carried out. This consists of making an incision about 2 in. from the anus on each side The skin up to the anal orifice is then undermined and the wound closed The rationale of the operation is to divide all the nerves passing to the affected area of skin.

PILONIDAL SINUS

This sinus is thought to be of developmental origin although it may result from repeated trauma and has no connection with the rectum or anus. It opens at the skin surface in the midline about 2 in

posterior to the anal margin The track which is lined by ectoderm and may contain hairs leads upwards and deeply towards the posterior aspect of the sacrum It often has many ramifications and complete extirpation may therefore be difficult

Operation may be demanded if the discharge from the sinus causes discomfort or if as often happens, the sinus becomes subject to low grade infection or abscess formation

To prevent post-operative recurrence—a common sequel—wide excision is necessary Methylene blue may be injected into the sinus to ensure that no side channel is overlooked.

Under general anæsthesia a vertical elliptical incision is made excising a wide strip of skin round the sinus The skin flaps are dissected back to either side and a strip of tissue, which may be 1½ in. wide and 3 in long is excised the dissection being deepened until the posterior aspect of the sacrum is reached

The subsequent procedure varies Most surgeons endeavour to obtain primary union and to do this devote special care to suturing the skin, using mattress stitches to obliterate the dead space or alternatively using deep stitches tied over a gauze roll others in view of the great tendency for the wound to become infected and break down prefer to pack it open and allow it to granulate

The post-operative care also is varied Permanent cure is best attained by continued recumbency until complete healing has taken place but since this may involve a stay in hospital for several weeks it is not always practicable

TUMOURS OF THE RECTUM

Rectal Polypus

This adenomatous tumour is commonest in children though it may occur in adults It may cause hæmorrhage and may prolapse through the anus giving rise to a cherry like protrusion which may be mistaken for a pile or a prolapse

The polypus can be removed by dividing its pedicle after ligating it General anæsthesia is necessary Usually the polypus can be seized in a forceps and brought down through the anus but if this is not possible the ligature may be applied through a proctoscope The ligature should transfix the pedicle lest it slip off and permit troublesome bleeding

Carcinoma of the Rectum

This common tumour is of slow growth and in the early stages is amenable to radical surgery Often unfortunately its early symptoms are attributed to piles and for this reason digital examination of the rectum should be carried out in all cases before this diagnosis is made

Digital examination apart from confirming the diagnosis is of value in assessing the operability of the tumour and determining the type of operation to be performed. Fixation anteriorly to the bladder

usually denotes inoperability, whereas fixation posteriorly is less important, for the tumour can generally be peeled off from the presacral tissues

In assessing operability the abdomen must be examined for enlargement of the liver and for free fluid denoting peritoneal metastasis while the general condition of the patient must be taken into account Unless there are clear contraindications, radical operation should generally be attempted since in its later stages a growth in the rectum gives rise to much discomfort and pain

For carcinoma the operation of combined removal ' is generally performed, consisting of an abdominal and a perineal stage Either part of the operation may be performed first—the abdomino-perineal or the perineo abdominal—or the operation may be carried out by two surgeons working together the one performing the abdominal part and the other the perineal part

A period of rest in bed with washing out of the bowel will often improve the patient s general condition very materially

Abdomino-perineal Operation.—The patient lies in the Trendelenburg position and the abdomen is opened by a right paramedian incision The tumour is examined to see that it is operable and a search is made for secondary deposits in the liver and the glands Provided the operation is feasible the pelvic colon is drawn up into the wound and the pelvic mesocolon divided The bowel is divided where the pelvic colon crosses the common iliac artery and the ends closed The proximal end is drawn through a small incision over the left iliac fossa and fixed to the parietal peritoneum to constitute the permanent colostomy The peritoneal reflection round the sides of the rectum is divided and the rectum separated from the bladder in front in the male or from the uterus and the vagina in the female Posteriorly the tumour can usually be peeled off the sacrum quite easily

After all the bleeding points have been controlled the pelvic colon and rectum are pushed into the pelvis and it may then be possible to close the peritoneum of the pelvic floor over the freed part of the bowel The abdomen is then closed

The patient is then placed in the lithotomy or the left lateral position and a rubber catheter is tied in in the male patient to mark the position of the urethra The anus is closed with a purse string suture of strong silk. An incision is made from over the coccyx forwards to encircle the anus This wound is deepened and the coccyx is disarticulated from the sacrum. As the wound is deepened through the fat of the ischio-rectal fossa the inferior rectal vessels are caught and ligated. The levatores ani are divided, carrying the division well forward to the anterior aspect of the rectum.

Posteriorly the rectum separates easily from the sacrum but anteriorly separation from the vagina or the urethra is more difficult The line of cleavage can usually be found by inserting a blunt-pointed pair of artery forceps and opening them Thus the line of cleavage is displayed, the recto-urethralis muscle is displayed and divided and the space of Denonvillier is opened At this stage the bowel will be found to be freed and is removed.

Fig 319
Perineal stage showing division of the levator ani muscle.
(Reproduced by permission from Gabriel's "Rectal Surgery")

Fig. 320
Freeing the anterior aspect of the rectum from the prostate.
(Reproduced by permission from Gabriel's "Rectal Surgery")

The large wound is lined with perforated oiled silk and a pack inserted The perineal wound is narrowed

When the perineal stage of the operation is carried out first, it is necessary to open the abdomen to look for secondaries The abdominal wall is closed temporarily and the perineal stage of the operation is embarked on (Fig 319) After the levatores ani have been divided a strong band will be felt on each side—the sling ligaments These are ligated in continuity and divided for they contain the middle rectal



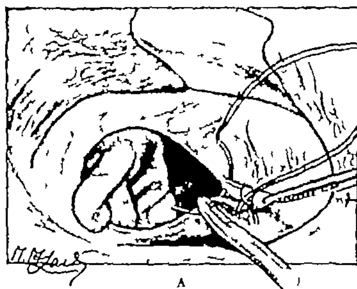
FIG. 321
The division of the peritoneum at the side of the rectum.
(Reproduced by permission from Gabriel's "Rectal Surgery")

vessels (Fig 320). Anteriorly after the space of Denonvillier has b opened the peritoneum is incised (Fig 321) The peritoneum is divi round the sides of the rectum as far posteriorly as possible

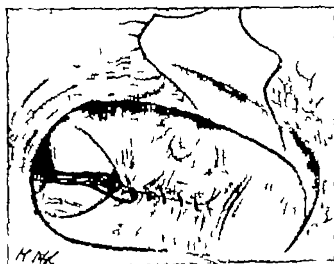
When all the bleeding points have been ligated the rectum pushed upwards as far as possible the anus having been cove with a sterile swab or a glove (Fig. 322) The wound is narrowed packed

The abdomen is reopened and after the insertion of a self retain retractor and the packing off of the small intestines the hand is pa into the pelvis and the rectum drawn up into the wound (Fig 3

The pelvic mesocolon is ligated so as to allow of the bowel being divided at about the level where the colon crosses the common iliac vessels (Fig 324) *A small incision is made over the left iliac fossa* and the rectum and pelvic colon are drawn through this up to the point where the bowel is to be divided The colon is stitched to the parietal



A



B

Fig. 322

The closure of the peritoneum from below

(Reproduced by permission from Gabriel's "Rectal Surgery")

peritoneum at the margins of this wound The peritoneum of the pelvis is closed with a continuous stitch and this will be found to be very easily performed

The abdomen is closed and as a final step clamps are applied to the colon and division carried out The clamp is left on the proximal

end of the colon for two or three days to allow the peritoneal cavity to become sealed off before the colostomy can function

It is customary in these cases to give the patient an intravenous drip before operation and to give blood by the drip method during and



Fig. 323

The appearance when the rectum has been drawn out of the abdominal wound, showing the line of section of the pelvic mesocolon.

(*Reproduced by permission from Gabriel's "Rectal Surgery"*)

after the operation aiming to give two pints of blood It is also an advantage to tie a catheter into the bladder for the first five or six days to save any difficulty with micturition which is very liable to occur with these cases

A full course of penicillin and sulphonamides is also given to reduce

the risk of infection of the perineal wound which used to occur four or five days after the operation

With tumours in the upper part of the rectum an attempt may be made to conserve the sphincters—the removal of the rectum by the anterior route The operation consists of freeing the pelvic colon and the upper part of the rectum from the abdomen A special clamp is applied to the rectum at least an inch below the tumour and the bowel divided After removal of the affected portion of the rectum along

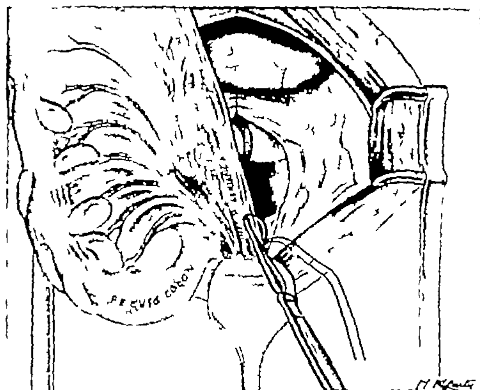


FIG. 324

The rectum has been drawn out of the abdominal wound and the vessels of the mesentery of the pelvic colon are being ligated.

(Reproduced by permission from Gabriel's "Rectal Surgery")

with the lower part of the pelvic colon and the glands continuity is restored by performing an end to-end anastomosis between the rectum and the pelvic colon A preliminary transverse colostomy may be carried out to give rest to the field of operation Penicillin and sulphonamides by controlling infection have made this operation safer and recently it has been shown that tumours in this situation tend to spread upwards only so that from the pathological point of view it is justifiable

CARCINOMA OF THE ANUS

This is a squamous carcinoma which generally forms an ulcerating growth involving the anal canal and the skin adjoining the anus. It metastasises to the lymph glands of the groin

The primary growth is amenable to radiotherapy though in most cases a preliminary colostomy is advisable to prevent fæcal contamination of the ulcerated surface If the growth is too extensive for radiotherapy a palliative colostomy should be performed

Interstitial radiation by radium needles is usually the method of choice The dose of irradiation must be calculated accurately and implantation of the needles must be carried out in close collaboration with the radiotherapist In favourable cases complete healing may be achieved

W A D A

CHAPTER XXXV

AFFECTIONS OF BILIARY TRACT, PANCREAS, AND SPLEEN

ACUTE CHOLECYSTITIS

ACUTE cholecystitis is almost always precipitated by the lodgment of a gall-stone in the neck of the gall bladder or in the cystic duct. Infection proceeds apace in the obstructed viscus; the gall bladder wall becomes inflamed, thickened and œdematous and the stagnant bile becomes increasingly purulent. If the infection is severe the disease may progress to gangrene and rupture of the gall bladder and to peritonitis. Fortunately in most cases the infection is milder and the tough gall bladder wall resists perforation, but nevertheless the disease is a severe one with much pain and considerable toxic absorption; convalescence often is slow and there is always a liability to subsequent attacks.

In these circumstances it would seem rational to cut short the disease, as is done in acute appendicitis, by removal of the inflamed viscus. This is the line of treatment in early cases now being advised increasingly by surgeons with special experience in this field.

The technical difficulties of operation for acute cholecystitis are, however, considerable. The patient usually is stout, access is difficult, the gall bladder is deeply placed, vascular and adherent, the liver is soft and friable, while there is a considerable risk of post-operative suppuration in the wound or in the subphrenic space. Consequently, unless there are special indications for operation (see below) it is customary to advise conservative treatment for the acute stage, operation being carried out three or four weeks later when the infection has subsided.

Conservative Treatment.—The patient is nursed in the semi-sitting position and the customary treatment for acute infective processes is given. Fluids with glucose are administered by mouth, unless there is much vomiting, and by the rectum. Morphia is generally necessary to ease the pain and should be given in full doses, for smaller amounts tend to cause spasm of the biliary sphincters and fail to give relief. Atropine may usefully be given along with the morphia. Large fomentations applied to the gall bladder region give great relief, but care must be taken to avoid blistering, as the skin in this region is hyperæsthetic and easily irritated. Sulphonamides may be administered.

Under conservative treatment the infection usually begins to subside after forty-eight hours or so, the temperature and pulse rate gradually settle and the pain and tenderness diminish. If improvement fails to occur a sharp lookout must be kept for signs indicating spread of the infection.

Operative Treatment.—The decision to operate in acute cholecystitis demands sound clinical judgment and a proper appreciation of the pathological process involved The two complications to be feared—and to be averted by timely operation—are acute perforation of the gall bladder which leads to biliary peritonitis and subacute perforation which leads to abscess formation in the subhepatic or subphrenic region

Acute perforation generally occurs early before adhesions have had time to form round the inflamed viscus Its imminence may be suspected if the onset of the acute attack is unusually abrupt and its early progress rapid and if palpation of the upper abdomen reveals a tense tender gall bladder protected by much rigidity of the rectus muscle

Subacute perforation generally occurs later It may be suspected if the symptoms do not subside under conservative measures if the leucocyte count increases progressively and if the zone of tenderness and rigidity below the right costal margin increases

Technique of Operation.—Apart from occasional cases seen very early in the acute attack the operation must be limited to cholecystostomy with removal of the stones The anæsthetic must be chosen and administered with care for the myocardium is toxic and often fat-laden and the liver is damaged moreover there is a considerable risk of post-operative pulmonary complications Cyclopropane is most suitable or failing this gas-oxygen-ether Local anæsthesia may be used in bad risk cases

The incision should be a short vertical one immediately over the point of maximum tenderness an inch or two to the right of the midline below the right costal margin The rectus muscle should be split rather than retracted to gain more direct exposure and drainage When the abdomen has been opened and explored the gall bladder region is walled off by hot packs If adhesions are present they are disturbed as little as possible and divided only sufficiently to expose the gall bladder at the fundus The rest of the operation is similar to cholecystostomy for chronic cholecystitis (p 650) If there has been soiling of the operation area in addition to the tube draining the gall bladder a further drain of dental rubber should be inserted in the vicinity of the gall bladder The wound should be closed by interrupted sutures tied lightly to avoid undue tension

CHRONIC CHOLECYSTITIS AND GALL-STONES

The indications for treatment differ according as the cholecystitis occurs alone or with gall-stones

In *non-calculous cholecystitis* the pathological changes are generally of mild degree the gall bladder wall is but little thickened and there is no obstruction to the flow of bile The symptoms also are mild and not always characteristic—flatulent dyspepsia with disturbance of digestion and irregular pain associated with reflex pylorospasm but no biliary colic and but little tenderness in the gall bladder region.

In this type of case the results of operative treatment are not

consistently satisfactory for cholecystostomy does little to relieve a condition which is essentially an intramural infection and may aggravate the symptoms by causing adhesions round the gall bladder while removal of the gall bladder in this early stage of disease prevents the concentration and intermittent discharge of bile and leads to continued dyspepsia

In non-calculous cholecystitis therefore the routine treatment should be by medical measures and operation should be advised only if they fail to effect relief

In *calculous cholecystitis* on the other hand the pathological changes are more pronounced The gall bladder wall is often thickened and more heavily infected while the stones are apt to cause persistent or recurrent biliary stasis The symptoms also though variable tend to be more severe especially in those cases where recurring impaction of a stone at the neck of the gall bladder leads to biliary colic Moreover there is always a liability to acute cholecystitis and a stone may migrate to the common duct and cause cholangitis Finally there is a risk, small but definite that eventually the chronic irritation of the stones will lead to carcinoma

All these considerations make it clear that the proper treatment of calculous cholecystitis is by operation which if properly performed gives a complete and lasting cure Medical treatment cannot of course dissolve the stones and cannot cause them to be expelled along the ducts but medical treatment has a definite place as an auxiliary to surgery for example in reducing obesity and making the patient fit for operation.

Medical Treatment.—Medical measures include diet to reduce obesity drugs to relax the biliary sphincters cholagogues to increase the biliary flow and symptomatic remedies for the associated dyspepsia.

The diet should be small and deficient in fats and lipoids It should be emphasised that such a diet does not affect the character of the bile and in particular does not reduce the bile-cholesterol content It can thus neither dissolve gall-stones nor prevent the formation of new stones Its value lies in reducing obesity and relieving the flatulent dyspepsia

Many methods have been employed to relieve biliary stasis and promote a free flow of bile Belladonna may be prescribed or trasentin which lacks the unpleasant side effects of atropine Bile salts are the most effective cholagogues known and are regarded as of some value Internal drainage by the duodenal tube has now been given up but small doses of magnesium sulphate by the mouth at frequent intervals are of benefit

Hexamine has a reputation as a biliary antiseptic but its effectiveness is doubtful Sulphanilamide is known to be excreted in the bile but at present we have little knowledge of its value in cholecystitis

For the associated dyspepsia a variety of medicaments have been recommended If hyperchlorhydria or hypochlorhydria is present it would seem rational to prescribe the appropriate remedy Olive oil has a reputation in the treatment of the dyspepsia probably by relieving pylorospasm. Some of its popularity both with patients and

charlatans may be attributable to the fact that when saponified in the small intestine it forms soapy masses which, when passed in the stools may be mistaken for gall stones Probably the most valuable method of treating the dyspepsia of cholecystitis is by regular doses of aperients

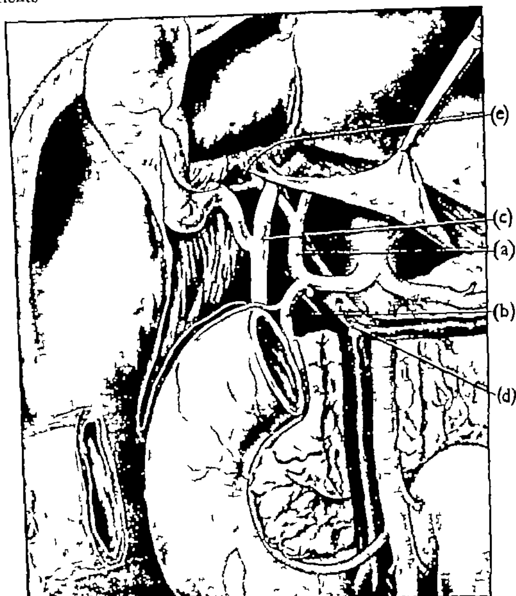


FIG 325

Anatomy of bile ducts and vessels.

(*a*) Hepatic artery (*b*) gastro-duodenal artery; (*c*) common bile-duct; (*d*) portal vein (*e*) cystic artery

Surgical Treatment.—The choice of operation lies between cholecystectomy (removal of the gall bladder) and cholecystostomy (drainage of the gall bladder) *There is now general agreement in* favour of cholecystectomy which eliminates the focus of infection precludes all possibility of recurrent stone formation and can be expected to provide a complete cure in the great majority of cases Cholecystostomy is advised only in cases where removal of the gall

bladder is rendered difficult by reason of deep access or dense adhesions or in the presence of marked jaundice or severe toxæmia

Technique of Cholecystectomy—General anæsthesia is required, preferably using cyclopropane The patient should be placed as shown in Fig 320 the lower thoracic spine being arched over a bridge or air pillow so as to displace the liver forwards

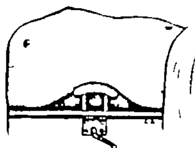


Fig 320
Position of patient for cholecystectomy

The most satisfactory incision is a paramedial one an inch or so to the right of the midline and extending from the costal margin downwards for 5 or 6 in Some surgeons however prefer Kocher's incision in which all the layers of the abdominal wall are divided below and parallel to the right costal margin It has the advantage of giving somewhat better access but is thought to carry a greater risk of herniation

When the abdomen has been explored and the diagnosis verified moist packs are introduced to isolate the region of the gall bladder and deep retractors inserted to hold the stomach and colon away from the operative field The congenital hepato-duodenal fold and pathological adhesions may require to be separated at this stage A forceps is now applied to the gall bladder near its neck and used to exert traction on the cystic duct which can thereby be identified.

At this stage the common duct is inspected and palpated If necessary the peritoneum overlying it may be stripped off to give a clear view Normally the common duct is thin walled and of blue-green colour If it is dilated or thickened and opaque if any stone is palpable within it or any induration felt in the pancreas along its course or if the clinical history points to a stone in the duct it should be explored as described below

To remove the gall bladder the first step must be to isolate the cystic duct and cystic artery and to define other structures in the vicinity which may be endangered It should be borne in mind that there are many anomalies of relationship in this region The neck of the gall bladder may be fixed by pathological adhesions to the duodenum or to the common duct The cystic duct may be so short that the common duct is drawn up when traction is applied and is in danger of being ligated or divided or the cystic duct may be so long and enter the common duct so far behind the duodenum that a stone impacted in it may be missed

The arteries also may be anomalous Normally the right hepatic artery passes behind the common duct up into the hilum of the liver to reach its destination alongside the right hepatic duct but it may pass in front of the common duct or may loop alongside the cystic duct and then is liable to be ligated in mistake for the cystic artery Such an error may lead to fatal necrosis of the right lobe of the liver

When the dissection has been completed the isolated cystic duct

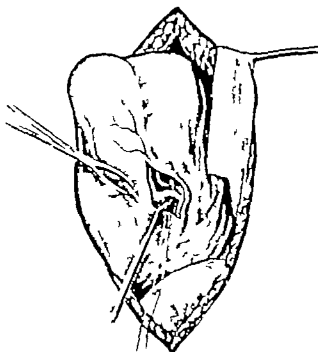


Fig 327
Cholecystectomy Exposure and ligation of cystic duct.

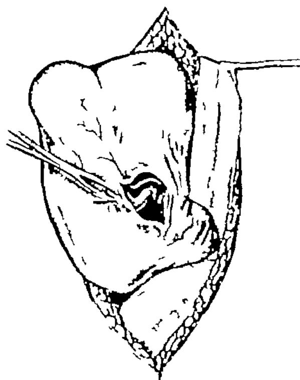


Fig 328
Cholecystectomy Cystic duct divided between ligatures.

Technique of Cholecystostomy—When the operation is performed for chronic cholecystitis the anæsthetic and the methods of incision are the same as for cholecystectomy When the abdomen has been explored packs and retractors are introduced and the biliary tract is examined with care Particular attention must be paid to the common bile duct which should be explored if the presence of a stone is suspected

To drain the gall bladder the fundus is first isolated from the rest of the operative field by packs If the gall bladder is distended it is evacuated by a special long curved trocar and cannula The cannula is then removed the opening in the fundus enlarged and any gall stones extracted For this purpose a fenestrated forceps may be used or a blunt scoop or the stones may be milked up towards the fundus by two fingers applied from without Particular care must be taken that all stones and fragments of stones are removed a small stone wedged in the cystic duct is especially apt to be missed

A rubber drainage tube the calibre of a lead pencil is now inserted and fixed to the edge of the gall bladder wall by a catgut stitch The fundus of the gall bladder may be invaginated through a purse string suture if desired though this step is unnecessary and not always practicable The gall bladder is not sutured to the abdominal wall. The drainage tube may be brought out at the upper end of the wound or if preferred through a separate stab wound a little to the lateral side It should generally be left in place for ten to twelve days

STONES IN THE COMMON BILE DUCT

Stones in the common bile duct typically give rise to jaundice variable in degree and sometimes associated with infection of the bile passages In some cases these features are mild and the general health is good and consequently no special pre-operative care is required In others—the minority—a severe grade of biliary obstruction develops with marked infection characterised by deep jaundice pyrexia and sometimes rigors and severe toxæmia In such circum stances the risks of operation are great and much care is required in deciding when and how the operation may best be performed.

The pre-operative preparation must be designed to overcome the biliary infection (cholangitis) and to counteract the effects of the biliary obstruction Fluids with glucose should be given by the mouth by the rectum or intravenously Hexamine may be advised though its value is very doubtful Sulphanilamide which is partly excreted in the bile may prove useful and should be tried Vitamin K should be given in doses of 10 mg daily preferably for a week prior to operation

The operation technique should be varied according to circum stances Generally the duct is exposed in its supraduodenal portion the stones are extracted and a drainage tube inserted after which if the patient is in good condition and there are no technical difficulties, the gall bladder is removed If the patient is very ill cholecystostomy may be substituted for cholecystectomy

behind Exploration of the duct is best carried out by a delicate pair of curved fenestrated forceps If a stone is encountered it is grasped with care to avoid fragmentation and gently withdrawn Often several stones are present in the duct and it is important that all should be removed To ensure removal of all fragments of stone and biliary deposit the duct may be flushed out with warm saline which may be instilled conveniently through a Eustachian catheter connected with a Higginson syringe To avoid flooding of the wound the fluid should be evacuated by suction as it escapes from the duct A probe should now be inserted and passed gently down into the duodenum to determine the patency of the sphincter of Oddi A Lister s bougie

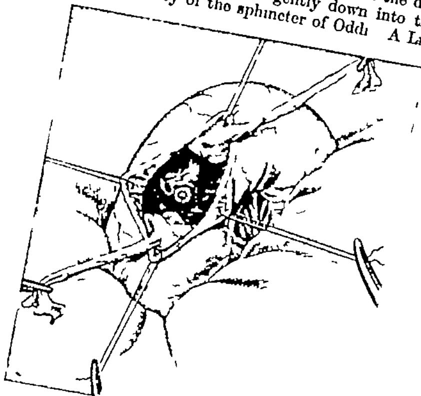


FIG. 333
Transduodenal exposure of common duct.

size 9 12 serves well for this purpose When the probe is in position careful palpation should be made along it to ensure that no stone has been overlooked

After removal of stones it is customary though probably not always essential to drain the duct A special T tube of flexible rubber is sometimes used for this purpose the short cross limbs of the T being inserted into the duct upwards and downwards respectively An alternative method is to use a simple rubber tube of suitable calibre inserted upwards into the duct The tube may be fixed in place by a single catgut stitch which picks up the edge of the opening in the duct The operation may then be completed by removing or draining the gall bladder as seems more appropriate Finally an additional drain of dental rubber should be inserted to the vicinity of the common duct in case of bile leakage The wound is now closed The drains

may be brought out through the main wound or through a separate stab wound. The tube draining the common duct should be left in place for twelve to fourteen days. It can conveniently be led to a bottle about 6-oz. capacity attached to the side of the binder.

Transduodenal and Retroduodenal Approach to Common Duct.—The supraduodenal approach described above is the routine method for gaining access to the common duct and is adequate in over 90 per cent. of cases. Occasionally, however, a stone impacted tightly at the lower end of the duct cannot be extracted by this route. In such circumstances more direct access must be gained.

In the transduodenal method the second part of duodenum is mobilised medially after dividing its lateral peritoneal reflection. The site of the stone is then established by palpation, and the duodenum opened at this level by a short vertical incision through its anterior wall. In these cases the stone is generally impacted in the ampulla of Vater or immediately above this point, and it is an easy matter to cut down on it from within the duodenum and extract it. The wound in the anterior duodenal wall is then closed, using two layers of fine silk sutures.

In the retroduodenal method the duodenum is mobilised well forwards as described above and drawn medially so that its posterior aspect is brought to view. The stone is then palpated and exposed by a short incision through that part of the head of the pancreas which lies behind the lower part of the duct. After the stone has been extracted the duodenum is allowed to fall back into place. A drain should be inserted down to the retroduodenal space and brought out by a stab wound in the loin.

POST-OPERATIVE STRICTURE OF THE COMMON BILE DUCT

This lesion results from damage to the common duct sustained in the course of cholecystectomy, and, though fortunately rare, it merits discussion in view of the difficult problems it presents.

The injury usually occurs when cholecystectomy is performed without adequate exposure, or when the field of operation is obscured by hæmorrhage. Under these conditions a hæmostat or clamp is applied by mistake to the common duct, which is crushed or severed. This is especially apt to happen if the common duct is knuckled by forcible traction on the gall bladder. Jaundice develops soon after the operation, progressively deepens and persists. The biliary obstruction may be complete or partial. Sometimes bile leaks at the wound and a biliary fistula develops. Infection of the stagnant bile commonly leads to cholangitis and to ascending infection of the bile passages.

The operative treatment is rendered difficult by dense adhesions which bind the stomach, duodenum and colon to the under surface of the liver. Good exposure is necessary, preferably by a Kocher incision. Great care is needed in separating the adhesions to avoid damage to the viscera, especially the thin walled duodenum. The dissection is deepened to the porta hepatis to expose the dilated duct above the

stricture At this stage there is a risk of damage to the portal vein and the hepatic artery and its branches

Once the duct has been displayed it may be anastomosed to the duodenum or to a limb of jejunum (brought up en Y as described on p 593) In favourable cases the anastomosis may be made to the lower end of the duct after mobilising the duodenum sufficiently to allow it to be brought up to meet the proximal portion The anastomosis may be made in the orthodox manner using fine silk sutures

This is one of the most difficult operations in the whole field of surgery and should emphatically be reserved for the expert

CARCINOMA OF THE HEAD OF THE PANCREAS

Under this title we include growths arising in the pancreas proper and also peri ampullary growths arising in the terminal parts of the bile and pancreatic ducts or in the ampulla of Vater

Carcinoma in this situation gives rise at an early stage to obstructive jaundice insidious in onset and progressively deepening Pain of a dull aching character is present in about 40 per cent of cases but is rarely severe Pruritus may be the first symptom and may be severe

Formerly the treatment was entirely palliative but in recent years the radical operation has been found to be practicable in early cases For this reason operation should always be advised provided that the general condition of the patient permits and that there are no obvious metastases in the liver or peritoneal cavity

Pre-operative Preparation.—Care is necessary to improve the general condition before operation The patient should be brought into hospital at least a week in advance If the appetite allows a high protein diet is given with adequate amounts of glucose Intravenous therapy may be necessary with physiological saline and 5 per cent glucose solution If as occassionally happens glycosuria is present insulin should be administered Transfusion of plasma or blood may be required and if necessary protein hydrolysate may be given

In addition to these general measures of pre-operation vitamin K (Kapilon) should be given in doses of 10 mg twice daily by intramuscular injection

Palliative Operations.—To short-circuit the biliary obstruction the gall bladder may be anastomosed to the stomach or jejunum

Cholecystgastrostomy—The gall bladder which is greatly distended is emptied by means of a trocar and cannula which should be inserted in the inferior aspect of the fundus The empty gall bladder is then brought into contact with the anterior aspect of the stomach some 3 in proximal to the pylorus and an anastomisis made the trocar wound being enlarged to a length of about 2 cm for the stoma Fine silk sutures are used and great care is necessary to guard against puncturing the thin walled gall bladder with risk of bile leakage This operation is apt to be followed by ascending infection of the bile passages For this reason cholecystjejunostomy is to be preferred

Cholecystjejunostomy—The gall bladder is emptied as before the puncture being made at the fundus The jejunum is divided about

10 to 12 in below the duodenojejunal flexure and the upper end implanted into the side of the jejunum some 8 in farther down The open end of the jejunum is then drawn up in front of the colon and joined by end to-end anastomosis with the fundus of the gall bladder In this way a segment of 8 in of jejunum is interposed between the biliary passages and the alimentary canal thus reducing the risk of ascending infection

Radical Operation.—This operation may be performed in two stages the first stage consisting of cholecystjejunostomy to relieve the biliary obstruction—or at a single session The latter method is to be preferred if the patient s condition permits The steps are as follows —

1 The hepatic flexure of the colon is displaced downwards and the duodenum mobilised forward after division of the peritoneal reflection to its outer side
2 The common duct is defined in the right free border of the lesser omentum and is divided
3 The duodenum is divided close to the pylorus (or better the stomach divided just proximal to the pylorus) and also in its third part The distal end is closed and invaginated. At this stage the gastroduodenal and pancreatico-duodenal arteries are ligated.
4 The superior mesenteric vein is defined as it passes behind the neck of the pancreas and its small tributary veins are ligated. The neck of the pancreas is then cut across
5 The common duct pancreatic duct and pyloric end of the stomach are then implanted severally (and in that order from above downwards) into the proximal jejunum which is brought up into the field of operation in front of the colon The common duct and the stomach are joined to the jejunum by end to-side anastomosis of orthodox type The pancreatic duct may be implanted through the agency of a vitallium tube or alternatively the whole thickness of the neck of the pancreas may be inserted into the side of the jejunum.

The principal complication is a *pancreatic fistula* owing to leakage from the site of pancreatic implantation It is dangerous owing to digestion of the skin (with consequent breakdown of the wound) and excessive loss of fluid which may amount to several litres daily To prevent digestion the skin is liberally coated with metallic aluminium ointment a fine catheter is inserted into the wound with continuous suction to aspirate all secretion The fluid balance is maintained by intravenous infusion Ephedrine (¾ grain) may be given to reduce the volume of pancreatic secretion

Total Pancreatectomy—In rare cases the whole pancreas has been removed for diffuse carcinoma The operation is but little more severe than that described above The disturbance of sugar metabolism resulting from the total ablation of islet tissue must be countered by appropriate injection of insulin Remarkably enough the dosage is not great varying from 15 to 40 units daily

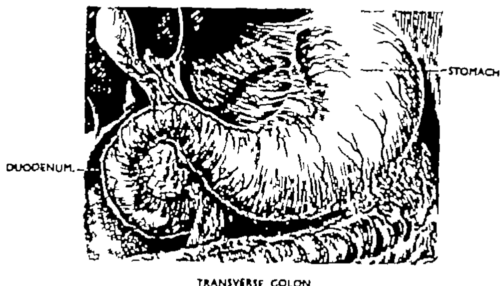


Fig. 334
Resection of Pancreas. 1 Colon and Duodenum mobilised.

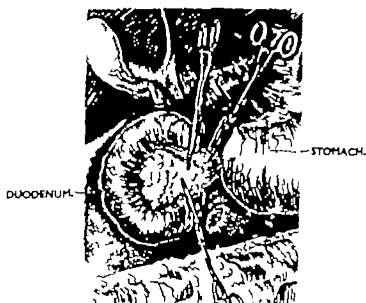


Fig. 335
Resection of Pancreas. 2. Common duct defined and divided. Pylorus and distal end of duodenum divided.

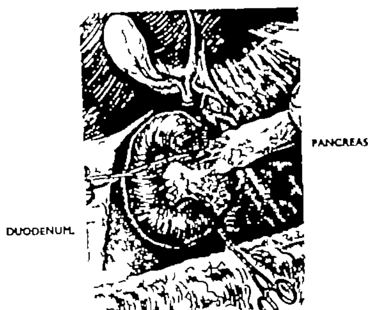


FIG. 336

Resection of Pancreas. 3. Superior mesenteric and portal veins defined.

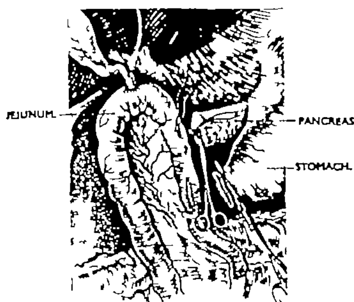


FIG 337

Resection of Pancreas. 4 The reconstruction. Common duct anastomosed to jejunum. Pancreatic duct cannulated ready to implant. Site of gastro-jejunal anastomosis indicated.

SURGERY IN OBSTRUCTIVE JAUNDICE

There are two special risks incident to operation for obstructive jaundice—hæmorrhage and liver failure These risks are rarely to be feared in mild jaundice such as is common as a result of stone in the common duct but are serious in deep jaundice of long standing such as results from malignant obstruction They are most to be feared after operation and particularly from two to six days after for it is at this time that the additional liver damage resulting from the operative trauma is at its greatest

Hæmorrhage in jaundice is now known to result from prothrombin deficiency which may be due partly to faulty absorption of vitamin K in the absence of bile from the intestine partly to faulty utilisation of the vitamin by the damaged liver The prothrombin content of the blood may be estimated by Quick s test in which the coagulation time is measured after the addition of an excess of calcium and tissue extract (thrombokinase) Normal blood so treated clots very rapidly (20 to 30 seconds) in prothrombin-deficient blood the clotting time is prolonged perhaps to five times that of the control

Administration of vitamin K remedies the prothrombin deficiency in all cases except those with extreme liver damage The vitamin dissolved in oil may be given intramuscularly the usual dose being 10 mg In severe cases this dose should be repeated daily for a week prior to operation and for a few days after operation

The danger of liver failure is less easily overcome In biliary obstruction the liver is enlarged and microscopically shows the signs of biliary cirrhosis and degenerative changes in the polygonal cells All its functions are impaired including its property of detoxifying the poisonous products of protein breakdown At present we have no specific therapeutic agent, but much can be done by attention to pre-operative preparation, operative technique and post-operative care Before operation fluids should be given in abundance and glucose to ensure an adequate storage of glycogen Generally it suffices to give glucose drinks by the mouth To prevent nausea unsweetened lime juice should be added (1 oz of lime juice suffices to render palatable 50 gm of glucose) In bad risk cases or where there is vomiting glucose salines may be given by the rectum or intravenously

At operation special care is taken to avoid unnecessary trauma and hæmorrhage In severe cases the operation should be restricted to the minimum necessary to relieve the jaundice If an anastomosis must be made meticulous care is required in its performance to obviate the risk of infection or leakage. After operation the fluid intake must be maintained and again glucose must be given usually by the intravenous route

ISLET-CELL TUMOUR OF PANCREAS

This tumour has the property of secreting insulin and gives rise to clinical features characterised by recurring episodes of hypoglycæmia The tumour though it has the microscopic characters of an adenoma

possesses no capsule and is embedded in the substance of the pancreas This feature and its small size may make difficult its identification and extirpation

In operating for islet-cell tumour it is necessary to allow for free exposure of the pancreas. An adequate incision is made at or close to the middle line If the stomach is low the pancreas may be inspected after opening through the lesser omentum in other cases the gastro-colic omentum is divided between ligatures to afford access

The body and tail of the pancreas should be inspected first since this is the commonest site for the tumour As has been indicated the tumour is generally of small size a centimetre or so in diameter while in some cases it is much smaller than this and may even be of micro scopic dimensions Generally it is somewhat more vascular than the normal tissue It is also rather firmer in consistency so it may be recognised more readily by palpation

If examination of the body and tail of the pancreas proves negative attention must be turned to the head of the gland To examine this part adequately it must be mobilised as described on p 655 so that it can be inspected both in front and behind and also palpated between fingers and thumb The unciform process must be included in the search

If the tumour is identified it is removed along with a zone of normal tissue the gap being closed and hæmorrhage being arrested by means of interrupted sutures If no tumour can be found and the clinical picture is sufficiently trustworthy it is recommended that the body and tail of the gland be removed in the hope that a minute tumour may exist in that situation

ACUTE PANCREATITIS

Acute pancreatitis varies greatly in severity from fulminating cases with hæmorrhages and extensive fat saponification to mild cases in which the pancreas shows little change beyond œdema and a few points of necrosis

Formerly operative treatment was the rule It is now recognised however that in most cases of mild or moderate severity the pancreatitis will subside under conservative treatment while in fulminating cases the operative mortality is high and there is good reason to believe that conservative treatment offers a better chance of survival

The diagnosis of pancreatitis can now be confirmed with a high degree of reliability by estimating the urinary diastase (amylase) which is greatly increased Nevertheless it often happens especially in the fulminating type of case that the abdomen is opened under the mistaken diagnosis of acute perforated gastric or duodenal ulcer or acute cholecystitis In such circumstances the peritoneal fluid should be evacuated and the gall bladder drained to relieve the pressure within the biliary system Some surgeons in addition advise that the peri toneum overlying the pancreas be incised and a large drain inserted down to the gland It would be a rational step also to explore the common duct for occasionally acute pancreatitis is due to reflux of

bile resulting from impaction of a stone at the lower end of the duct. *Generally however the poor condition of the patient* and the difficulties of access render such an exploration difficult during the acute stage

The post-operative course is often difficult and the mortality is high There may be much nausea with vomiting and retching Discharge along the drainage track persists for a long time and sometimes there are large sloughs of fatty tissue to be evacuated An abscess may form in the lesser peritoneal sac and require additional drainage

Under conservative treatment also convalescence is usually slow with nausea vomiting and retching There is no specific treatment Fluids with glucose should be given by the rectum or intravenously Atropine is sometimes advised to reduce the enzyme activity of the pancreatic juice The urine should be examined frequently for glycosuria, which occasionally develops and if necessary insulin should be administered

After recovery from the acute attack an X ray investigation of the gall bladder should be carried out and if there is evidence of cholecystitis or gall stones operative treatment should be undertaken Anastomosis of the gall bladder to the stomach duodenum or jejunum has been advocated with the object of diverting the bile and thus reducing the risk of reflux of bile into the pancreatic duct The value of this operation is not yet fully established

AFFECTIONS OF THE SPLEEN

Indications for Splenectomy —Splenectomy is indicated for injuries to the spleen for undue mobility of the spleen for the rare tumours and cysts and for certain diseases of the blood and reticulo-endothelial tissues

In this latter group of diseases the indications for operation are becoming more clearly defined and closely restricted. Operation is no longer advised in obscure anæmias merely because the spleen is palpably enlarged it is performed only when there is clear evidence that the spleen is at least partly responsible for the blood disorder Such evidence must be based upon repeated examination of the blood including red and white cells and platelet counts reticulocyte counts and estimations of red cell fragility

Acholuric jaundice is the disease most amenable to splenectomy In the congenital or familial type especially operation may be relied upon to provide a complete and permanent cure in a large proportion of cases The jaundice fades rapidly and within a few weeks the blood count returns to the normal level, even though the red cell fragility does not always disappear

Thrombocytopænic purpura also is amenable to operative treatment in a considerable proportion of cases One of the most dramatic of all operative cures is seen in cases with prolonged severe and almost fatal hæmorrhage where splenectomy may cause immediate and complete cessation of the bleeding Such gratifying results are not however to be expected invariably and indeed in something like 30 per cent of cases splenectomy either fails to arrest the hæmorrhage or is followed by late recurrence

Splenic anæmia, (Banti's syndrome) is now only rarely treated by simple splenectomy The spleen may require to be removed, however as part of the operation of lienorenal anastomosis (p 663)

Splenectomy is indicated also for Egyptian splenomegaly It has been advised occasionally in malaria if the spleen remains enlarged despite thorough antimalarial treatment and appears to be a focus for the parasites Similarly it has been advised in syphilitic enlargement of the spleen in cases in which repeated courses of treatment fail to influence the Wassermann reaction and to reduce the splenomegaly

Splenectomy is contraindicated in polycythæmia in leukæmia, and in pernicious anæmia

Technique of Splenectomy—Pre-operative preparation is required to combat the anæmia which is nearly always present Blood trans



Fig 338

(1) Splenectomy Divisions of gastro-splenic and phrenico-colic ligaments.
(2) Splenectomy Spleen retracted forwards and to right; peritoneal reflection to diaphragm being divided.
(3) Splenectomy Vessels in lienorenal ligament being ligated. Tail of pancreas exposed and avoided

fusion is generally necessary In mild cases of acholuric jaundice one pint may suffice but in cases with severe anæmia or active hæmorrhage several pints may be required either by continuous infusion or repeatedly to make the patient fit for operation More blood should be available for administration during and after operation. Immediately before operation a stomach tube should be passed and suction applied The stomach is thus deflated and access to the spleen is improved

The most suitable incision is a left paramedian one one inch or so to the left of and parallel to the midline and extending upwards to the costal margin

When the abdomen has been explored the spleen must first be freed so that it can be presented at the wound and then removed It is important to gain adequate mobilisation first so that the splenic vessels can be controlled digitally and ligated under direct vision Mobilisation is a simple matter unless there are extensive adhesions between the spleen and the diaphragm Such adhesions must be divided with care to avoid damage to the diaphragm for then bleeding is apt to be profuse and difficult to arrest If the adhesions are dense

and vascular it may be necessary to abandon the attempt to remove the spleen

Apart from adhesions to mobilise the spleen involves three distinct steps First the avascular connections between the lower pole and the left colic flexure must be separated by blunt dissection. Secondly the gastrosplenic omentum must be divided At this stage the left gastro-epiploic vessels and the short gastric veins must be divided between ligatures If the spleen is large and vascular these veins may be short and very dilated and ligation of the uppermost vessels may well be delayed until the next step has been accomplished. This the third stage of mobilisation consists in dividing the peritoneal reflection which passes from the left side of the splenic pedicle on to the diaphragm The division is carried out simply by means of a long handled scalpel, the spleen meanwhile being retracted forwards and medially by the left hand Once the peritoneal anchorage has been divided the spleen can be drawn forwards and presented at the wound

There remains the splenic pedicle containing the splenic artery and vein (or their branches and tributaries) and the tail of the pancreas. It is a simple matter to dissect the vessels free and to ligate them first the artery and then the veins Finally when all bleeding has been arrested the abdomen is closed

PORTAL HYPERTENSION BANTI'S SYNDROME SPLENIC ANÆMIA

It is now recognised that the splenic enlargement of Banti s syndrome is due to elevation of the blood pressure within the portal venous system which is itself the result of obstruction to the portal blood flow caused by hepatic cirrhosis or rarely by other lesions of the liver the portal vein or its tributaries These rarer lesions include thrombosis of the hepatic veins thrombosis or congenital obliterations of the portal vein and thrombosis of the splenic vein which may be post traumatic The portal hypertension leads to splenomegaly to the development of collateral channels between the portal and systemic circulations, and eventually to ascites

Apart from the rare thrombosis of the splenic vein (for which splenectomy is indicated) the treatment advised recently has been to reduce the hypertension by performing an anastomosis between veins of the portal and systemic systems The splenic vein may be joined end to-end with the left renal vein (after removal of the spleen and left kidney) or end to-side the left kidney being preserved. Alternatively and in some respects preferably the portal vein may be divided and implanted into the front of the inferior vena cava

The value of these operations is still under discussion and alternative procedures are being explored

The indications for operation are (*a*) recurrent severe bleeding from œsophageal varices (*b*) severe resistant incapacitating anæmia (*c*) the development of ascites

Operation is contraindicated in the presence of severe liver damage as assessed by liver function tests and by aspiration trophy of the liver Before operation (if lienorenal anastomosis is contemplated)

it is also necessary to make sure by intravenous pyelography that the right kidney is present and of healthy function

Lienorenal Anastomosis.—To gain adequate exposure, a transverse or oblique subcostal incision is used The spleen is mobilised as described above The splenic artery is divided The smaller tributaries of the splenic vein are ligated close to the hilum in such a way as to preserve as much as possible of the main stem of the vein which is held lightly occluded by a delicate spring clamp The spleen is then removed

The left kidney is now exposed after downward displacement of the left colic flexure and is freed and mobilised The renal artery is ligated and divided The renal vein is mobilised with care to avoid damage to the suprarenal vein and to such occasional tributaries as enter it from the region of the diaphragm The vein is held lightly with a spring clamp and divided as close to the hilum as possible

The veins may be joined by a simple continuous mattress suture of finest silk applied so as to evert the intima and with care to avoid purse stringing

If it is necessary to preserve the left kidney the splenic vein may be implanted by means of a cannula into the side of the renal vein

Porto-caval Anastomosis —This operation is preferable as it offers a larger anastomosis which is less liable to be occluded by thrombosis or scarring

An oblique right subcostal incision is used The hepatic flexure duodenum and head of pancreas are mobilised as described on p 655 The portal vein is exposed as it lies in the right free border of the lesser omentum and traced upwards into the porta hepatis After a light spring clamp has been applied the vein is divided as high as possible

The vena cava already exposed and freed is now held at a suitable point by a special clamp designed to avoid complete occlusion (which if prolonged would cause severe renal damage) An incision is made in the front of the vein and the portal vein is then implanted by end to-side anastomosis

Post-operative Complications.—Apart from oozing from the anastomosis the main technical complication to be feared is the occurrence of thrombosis within the veins at the suture line Fortunately the strong current of blood due to the difference in pressure tends to prevent excessive clotting Heparin should not be given owing to the risk of hæmorrhage

C. F W I

REFERENCES

AIRD J (1948) "The Surgery of the Biliary System. *Annals of Royal College of Surgeons of England* **2**, 104

BLAKEMORE, A. H (1948). "Porto-caval Anastomosis. *Surgical Clinics of N America*, **28**, 279

BLAKEMORE, A H and LORD J W (1945). "Portal Hypertension. *Ann Surg.*, **122**, 476.

BLALOCK A (1947). *Ann Surg* **125**, 129

COLE, W H, IRENEUS C., and REYNOLDS, J R. (1945). "The use of Vitallium Tubes in Stricture of the Common Duct *Ann Surg.*, **122**, 490.

[illegible] F M., and MASON J C (1946). "Reconstructive Operations for Benign Stricture of Bile Ducts." *Surg. Gynec Obst* **83**, 74

LAHEY, F. H. (1937). "Stricture of Common and Hepatic Ducts." *Ann. Surg.*, **105**, 765.
MAINGOT (1941). "Resection of Head of Pancreas and Duodenum for Carcinoma." *Lancet*, **2**, 708.
MILLER, S. M., and WIPER, T. B. (1944). "Physiologic Observations on Patients with Pancreatic Fistula." *Ann. Surg.*, **120**, 85.
MORLEY, J. (1947). "Carcinoma of the Ampulla of Vater." *Brit. J. Surg.*, **35**, 146.
PACK, G. T., and BOOKER, R. J. (1948). "The Surgical Problems of Periampullary Carcinoma." *Arch. Surg.*, **5**, 7, 71.
PAXTON, J. R., and PAYNE, J. H. (1948). "Acute Pancreatitis." *Surg. Gynec. Obstet.*, **86**, 69.
VAN BUREN, G., and CURTIS, G. M. (1948). "Splenectomy in Childhood." *Arch. Surg.*, **56**, 125.
WELCH, C. S. (1947). "A Technique for Porto-caval Anastomosis." *Surg. Gynec. Obstet.*, **85**, 492.
WHIPPLE, A. O. (1945). "Pancreatico-duodenectomy for Islet Carcinoma. Five Year Follow-up." *Ann. Surg.*, **121**, 847.
WHIPPLE, A. O. (1945). "Portal Hypertension in Relation to Hepato-Splenopathies." *Ann. Surg.*, **122**, 449.

CHAPTER XXXVI

AFFECTIONS OF THE APPENDIX

INDICATIONS FOR TREATMENT OF ACUTE APPENDICITIS

EARLY operation is now generally agreed to be the best treatment for all save the mildest forms of acute appendicitis In mild appendicitis resolution takes place in many cases but not in all and early operation as a routine is advised because it combines immediate safety with the certainty of freedom from recurrence In severe appendicitis the need for operation is clearly urgent for within twelve or twenty four hours the appendix may become gangrenous and rupture Routine early operation is particularly desirable in childhood when appendicitis often changes from a mild to a severe type within the course of a few hours and in old age when appendicitis (though uncommon) often progresses rapidly

The contraindications to operation are few When the patient is not seen till the third or fourth day after the onset operation is withheld if there is evidence that the infection is subsiding or is being successfully localised. If infection is subsiding operation—apart from being superfluous—is made difficult by friable adhesions which persistently ooze blood. If infection is being localised to the right iliac fossa by the matting together of omentum and bowel, a tender mass is formed which it is unwise to disturb conservative treatment may lead to cure while if an abscess persists it is easily drained when it has become firmly sealed off In early pregnancy any lower abdominal operation is liable to cause abortion and operation is better avoided unless appendicitis is severe or is becoming worse under observation Similarly operation may be better avoided when appendicitis arises in the course of an acute illness

Immediate operation is carried out unless there is a definite contraindication The operation may comprise appendicectomy with or without drainage or (in rare instances) drainage alone the choice of procedure is discussed under operative technique (p 669) The best results are obtained when operation is performed before infection has permeated the wall of the appendix. If early operation is to be made possible in every case the patient as well as the family doctor must co-operate with the surgeon The patient should therefore be encouraged to seek advice at once without first trying various household remedies Of these castor-oil in particular is to be condemned because chemical irritation intensifies the effect of the bacterial irritation already present and because powerful peristaltic movement interferes with the protective adhesion of omentum and bowel round the infective

focus The family doctor having diagnosed acute appendicitis should arrange for immediate admission to hospital and should withhold hypnotics till the surgeon has agreed with the diagnosis and accepted responsibility for the care of the patient

INDICATIONS FOR TREATMENT OF RECURRENT AND CHRONIC APPENDICITIS

Operation may be required to obviate the risk of recurrence after an attack of acute appendicitis or to relieve the symptoms of chronic appendicitis Thus it may be indicated —

1 After acute appendicitis treated conservatively or by simple drainage Recurrence may be expected sooner or later in a large proportion of cases and should be anticipated by timely operation carried out after an interval of one to three months when congestion and infection have subsided
2 After mild recurring attacks of appendicitis or appendicular colic
3 In chronic appendicitis characterised by tenderness over the appendix with or without dyspepsia
4 *As an incidental step in the course of laparotomy for other pur*poses when there is evidence that the appendix is abnormal

TECHNIQUE OF THE INTERVAL OPERATION

The scope of the operation includes removal of the appendix and examination of the accessible viscera Routine pre-operative preparation is unnecessary The ritual of giving an aperient and an enema survives by custom but is said to increase the incidence of post-operative colic It is certainly common experience that patients so prepared do not enjoy a smoother convalescence than many unprepared patients operated upon for mild acute appendicitis General or spinal anæsthesia may be used

Many *incisions* are available and the choice largely depends on the surgeon s individual preference The two incisions in most common use are the grid iron (McBurney) and the pararectal (Battle) The grid iron incision affords rather limited access but since the approach is valvular the wound is strong The pararectal incision affords wider access and is favoured in women since it allows thorough examination of the pelvic organs A paramedian incision is used if very thorough exploration is indicated or if a gynæcological operation may also be necessary it has the particular advantage that it can be extended widely An oblique muscle-cutting incision is not used as a formal incision for the *interval operation but is valuable as a modification* of the grid iron incision when the access proves inadequate

Grid Iron Incision.—The incision is 3 to 4 in in length and is situated obliquely as illustrated a third of the way from the anterior superior iliac spine to the umbilicus The incision is carried down to the strong fibrous external oblique aponeurosis which is split in the whole length of the skin incision after being picked up to avoid injury to the sub jacent ilio inguinal nerve Retraction medially exposes the edge of the rectus sheath with the muscular fibres of the internal oblique running

almost horizontally from it Internal oblique and transversus as a single layer are split by blunt dissection in the line of their fibres Transversalis fascia and peritoneum are picked up together (or in succession if there is much extraperitoneal fat) a finger breadth from the edge of the rectus sheath and divided in the line of the skin incision, care being taken not to injure subjacent bowel The incision is later repaired in four layers by (1) a continuous suture uniting the edges of peritoneum and transversalis fascia as one layer (2) two or three loosely tied sutures approximating transversus and internal oblique as one layer (3) a continuous suture uniting external oblique and (4) suture of the skin edges

The *oblique muscle-cutting incision* is similar to the grid iron save that internal oblique and transversus are divided in the line of the skin

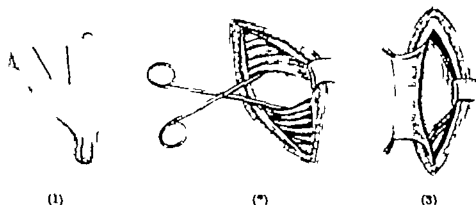


FIG 330

Appendicectomy (1) Incisions. (2) Grid iron approach; external oblique aponeurosis split and deeper muscles separated to expose fascia transversalis and peritoneum. (3) Pararectal incision; flap of rectus sheath turned laterally and muscle drawn medially to expose posterior sheath and peritoneum.

incision The divided muscles are later repaired as one layer by a row of interrupted catgut sutures

Pararectal Incision—The incision is 3 or 4 in in length and is made parallel with the midline and 2 in to the right of it as shown in the illustration The incision is deepened to the strong fibrous anterior wall of the rectus sheath which is divided a finger breadth medial to the linea semilunaris in the whole length of the skin incision the sheath divides in two distinct layers By blunt dissection the lateral margin of the rectus muscle is easily shelled out of its sheath and retracted medially During this process branches to the muscle from the lower thoracic nerves accompanied by small vessels, are seen and carefully displaced. Extension of the incision can be obtained only by sacrificing these nerves at the risk of causing subsequent incisional hernia The posterior rectus sheath and peritoneum are picked up again a finger breadth medial to the linea semilunaris and divided vertically to give as much access as required, care being taken not to injure subjacent bowel In dividing downwards the inferior epigastric vessels are avoided as they pass from below upwards and medially The incision is later repaired in three layers by (1) a continuous suture

uniting peritoneum and posterior wall of the rectus sheath as one layer the rectus muscle thereafter being allowed to fall laterally into place (2) a continuous suture uniting the two leaves of the anterior wall of the rectus sheath as one layer and (3) suture of the skin edges

The *paramedian incision* is similar to the pararectal, but is made a finger breadth to the right of the midline and the rectus muscle is displaced laterally Since no motor nerves are divided the incision can be extended widely

Excision of the Appendix.—The appendix seldom appears at the wound and must usually be sought It can be located by tracing the ascending colon down to the cæcum By drawing the cæcum and termination of the ileum firmly downwards out of the wound before turning them up the appendix is exposed freely Any adhesions which may be present are put on the stretch by gentle traction on the meso-appendix These adhesions are usually filmy and can be divided without bleeding they should be divided from the lateral side since the appendicular branches of the ileocolic vessels approach from behind and medially The meso-appendix, now freely exposed is ligated and divided A purse-string suture of fine catgut picking up serous and muscular coats is inserted into the cæcum ½ in from the root of the appendix The root of the appendix is occluded by a strong ligature and by a clamp distal to the ligature Between these the appendix is divided by a knife dipped in pure carbolic The stump of the appendix is invaginated into the cæcum and the purse-string suture tightened and tied off, a further sero-muscular suture across the invagination gives added security The ligated meso appendix is re-examined for bleeding points before the cæcum is returned to the abdomen a step which is facilitated by first expressing the contained gas Before closing the abdomen the accessible organs are examined including the terminal 3 or 4 ft of ileum (looking especially for ulcers stricture or Meckel's diverticulum) the ileal mesentery and ileocæcal angle (enlarged lymph glands) the back of the umbilicus (an occasional fibrous band) and in the female the uterus and its adnexa

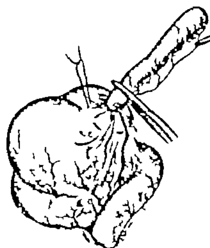


FIG 340

Appendicectomy Cæcum drawn out of wound, meso-appendix divided, base of appendix ligated, purse-string stitch inserted.

Careful record should be kept both of the extent of the examination and of the abnormalities found and a copy should be sent to the family doctor who is in a position to make most use of the knowledge gained.

THE EMERGENCY OPERATION

Pre-operative Treatment and Scope of Operation—No pre-operative treatment is usually required. Occasionally when the patient is in a

very toxic state the delay of a few hours for rest, warmth and the administration of fluids will reduce risk during the operation and the immediate post-operative period Either general or spinal anæsthesia is suitable while if these are contraindicated recourse may be had to local anæsthesia

Choice of Incision.—The grid iron is a suitable standard incision for the emergency operation. It can freely be modified by dividing across internal oblique and transversus if the original exposure prove inadequate Direct access to the cæcum is thus obtained without disturbing the ileum and so risking the spread of infection A para rectal or a paramedian incision is preferred when the inflamed appendix is thought to lie in the pelvic position again with the object of gaining direct access

Excision of the Appendix.—When the peritoneum is opened a little free fluid sometimes containing flakes of fibrin may escape This is a reactionary exudate from the inflamed peritoneum and does not of itself indicate that drainage will be required (The escape of frank pus at this early stage suggests that drainage should be instituted and removal of the appendix deferred to a second operation while the escape of copious amounts of fluid suggests that the diagnosis is at fault) The region of the cæcum and appendix is carefully examined by sight and by gentle palpation with the finger The inflamed appendix is easily felt as a tense resistant cord and in more than half of the cases of acute appendicitis lies lateral to or behind the cæcum Removal of the appendix is carried out usually without difficulty The appendix may be adherent to neighbouring structures if infection has penetrated deeply into its wall. From bowel parietal peritoneum and omentum it is usually separated easily by the finger but if a tag of omentum proves to be firmly adherent this is ligated divided and removed *en bloc* with the appendix In the absence of rupture of the appendix or of an abscess the incision is closed without drainage If however rupture has taken place (or if it should occur during manipulation) packs are gently inserted to prevent further contamination before proceeding with removal of the appendix and the incision is closed with drainage Similarly drainage is added when a small pocket of pus is opened into in the course of mobilising the appendix If a large abscess is encountered, however it may be wise to be content with drainage alone for simple drainage is often life-saving Thus if the abscess lies below or medial to the cæcum and the appendix is buried in adhesions there is a grave risk of disseminating infection in attempting its removal. On the other hand, if the abscess lies lateral to the cæcum there is little increased risk and removal of the appendix may be undertaken

When the tip of the appendix is difficult to locate or to mobilise there are two manœuvres which may help The first and more generally useful is to enlarge the access The grid iron incision, as already pointed out is easily enlarged by dividing internal oblique and transversus in the line of the skin incision. Extension of the pararectal incision is seldom required as access is already free The second manœuvre is to remove the appendix retrograde The root of the

uniting peritoneum and posterior wall of the rectus sheath as one layer the rectus muscle thereafter being allowed to fall laterally into place (2) a continuous suture uniting the two leaves of the anterior wall of the rectus sheath as one layer and (3) suture of the skin edges

The *paramedian incision* is similar to the pararectal but is made a finger breadth to the right of the midline and the rectus muscle is displaced laterally Since no motor nerves are divided the incision can be extended widely

Excision of the Appendix.—The appendix seldom appears at the wound and must usually be sought It can be located by tracing the ascending colon down to the cæcum By drawing the cæcum and termination of the ileum firmly downwards out of the wound before turning them up the appendix is exposed freely Any adhesions which may be present are put on the stretch by gentle traction on the meso-appendix These adhesions are usually filmy and can be divided without bleeding they should be divided from the lateral side since the appendicular branches of the ileocolic vessels approach from behind and medially The meso-appendix now freely exposed is ligated and divided A purse-string suture of fine catgut picking up serous and muscular coats is inserted into the cæcum ½ in from the root of the appendix The root of the appendix is occluded by a strong ligature and by a clamp distal to the ligature Between these the appendix is divided by a knife dipped in pure carbolic The stump of the appendix is invaginated into the cæcum and the purse-string suture tightened and tied off a further sero-muscular suture across the invagination gives added security The ligated meso-appendix is re-examined for bleeding points before the cæcum is returned to the abdomen a step which is facilitated by first expressing the contained gas Before closing the abdomen the accessible organs are examined including the terminal 3 or 4 ft of ileum (looking especially for ulcers stricture or Meckel s diverticulum) the ileal mesentery and ileocæcal angle (enlarged lymph glands) the back of the umbilicus (an occasional fibrous band) and in the female the uterus and its adnexa

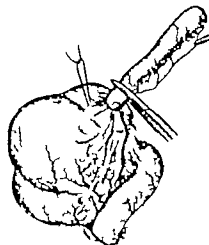


FIG 340

Appendicectomy Cæcum drawn out of wound, meso-appendix divided base of appendix ligated, purse-string stitch inserted.

Careful record should be kept both of the extent of the examination and of the abnormalities found and a copy should be sent to the family doctor who is in a position to make most use of the knowledge gained

THE EMERGENCY OPERATION

Pre-operative Treatment and Scope of Operation —No pre-operative treatment is usually required Occasionally when the patient is in a

very toxic state the delay of a few hours for rest warmth, and the administration of fluids will reduce risk during the operation and the immediate post-operative period Either general or spinal anæsthesia is suitable while if these are contraindicated recourse may be had to local anæsthesia

Choice of Incision —The grid iron is a suitable standard incision for the emergency operation It can freely be modified by dividing across internal oblique and transversus if the original exposure prove inadequate Direct access to the cæcum is thus obtained without disturbing the ileum and so risking the spread of infection A para rectal or a paramedian incision is preferred when the inflamed appendix is thought to lie in the pelvic position again with the object of gaining direct access

Excision of the Appendix.—When the peritoneum is opened a little free fluid sometimes containing flakes of fibrin may escape This is a reactionary exudate from the inflamed peritoneum and does not of itself indicate that drainage will be required (The escape of frank pus at this early stage suggests that drainage should be instituted and removal of the appendix deferred to a second operation while the escape of copious amounts of fluid suggests that the diagnosis is at fault) The region of the cæcum and appendix is carefully examined by sight and by gentle palpation with the finger The inflamed appendix is easily felt as a tense resistant cord and in more than half of the cases of acute appendicitis lies lateral to or behind the cæcum Removal of the appendix is carried out usually without difficulty The appendix may be adherent to neighbouring structures if infection has penetrated deeply into its wall From bowel parietal peritoneum and omentum it is usually separated easily by the finger, but if a tag of omentum proves to be firmly adherent this is ligated divided and removed *en bloc* with the appendix In the absence of rupture of the appendix or of an abscess the incision is closed without drainage If however rupture has taken place (or if it should occur during manipulation) packs are gently inserted to prevent further contamination before proceeding with removal of the appendix, and the incision is closed with drainage Similarly drainage is added when a small pocket of pus is opened into in the course of mobilising the appendix If a large abscess is encountered however it may be wise to be content with drainage alone for simple drainage is often life-saving Thus if the abscess lies below or medial to the cæcum, and the appendix is buried in adhesions, there is a grave risk of disseminating infection in attempt ing its removal On the other hand if the abscess lies lateral to the cæcum there is little increased risk, and removal of the appendix may be undertaken

When the tip of the appendix is difficult to locate or to mobilise there are two manœuvres which may help The first and more gener ally useful is to enlarge the access The grid iron incision as already pointed out is easily enlarged by dividing internal oblique and transversus in the line of the skin incision Extension of the pararectal incision is seldom required as access is already free The second manœuvre is to remove the appendix retrograde The root of the

appendix is divided between a ligature and a clamp and both cut surfaces are carbolised The stump of the appendix is invaginated into the cæcum in the usual way by a purse-string suture Between appendix and cæcum lies the mesentery of the appendix and this can relatively easily be traced and divided between successive pairs of hæmostats

Drainage of the wound is best obtained by a roll of fine sheet rubber (rubber dam dental rubber) This is efficient and being pliable, does not damage bowel with which it lies in contact The drain is led out of that part of the incision in which it lies most readily The peritoneum is closed as completely as possible short of constricting the drain The remaining layers of the wound however are either loosely approximated by a few sutures or left widely open according to the degree of infection likely to follow Drainage of the pelvis is best obtained through a small midline suprapubic stab incision and drainage of the lateral side of the cæcum can be obtained through a stab incision in the flank With such stab incisions thick walled rubber tubing in which a number of side-openings have been cut is more satisfactory than sheet rubber since the latter is liable to be constricted

POST-OPERATIVE CARE

After simple appendicectomy post-operative care presents little difficulty The patient appreciates the relaxation of the abdominal wall obtained by raising the shoulders and knees on pillows Morphia is seldom required after the second night Retention of urine may require to be treated as described on p 11 Intestinal colic is sometimes troublesome when peristalsis recommences on the second or third day the pains are relieved by a flatus enema such as glycerin (4 oz) with water (2 oz) followed if necessary by a soap and water enema Colic ceases after the first movement of the bowels usually secured by a mild aperient (such as liquid extract of cascara sagrada *1 dram) given on the third or fourth evening Water is allowed* freely after the cessation of post anæsthetic vomiting The diet is restricted to fluids till the bowels have moved If the temperature remains normal the wound is not dressed till the sixth or eighth day when the superficial stitches are removed Tension sutures are removed a couple of days later and the patient allowed up the same evening The patient leaves hospital on the tenth to the fourteenth day for a fortnight s holiday Light work may be begun a month after operation but for heavy labouring an interval of at least six weeks is insisted upon Longer convalescence is desirable if the patient can afford the loss of wages

After appendicectomy with drainage there are a few modifications in the post-operative care Thus as soon as the patient has recovered from the anæsthetic he is propped up on pillows so that gravity may aid drainage The wound is dressed daily or twice daily to prevent the skin becoming sodden with discharge The drain is shortened and removed after five or six days and the resulting sinus closes within a week or two the patient being kept in bed till healing has occurred

Complications following Operation—Complications are rare following the "interval operation" and following operation done in the early stages of acute *appendicitis*. They are common in neglected cases when infection has had time to extend beyond the appendix. Apart from the complications which may occasionally follow any abdominal operation, those deserving special notice are residual abscess, paralytic ileus, fæcal fistula and pylephlebitis.

RESIDUAL ABSCESS.—An abscess may arise during the course of acute appendicitis or as a complication in the post-operative period. Such abscesses usually lie in the right iliac fossa or in the pelvis, but may occasionally be situated elsewhere in the abdomen. Incision and drainage are deferred till it is clear that resolution will not occur or till increasing toxæmia indicates *that the pus is under tension*.

Abscess in the Right Iliac Fossa.—Under gas oxygen anæsthesia a small oblique incision is made over the lateral part of the abscess and all layers of the abdominal wall divided in the line of the skin incision. The peritoneum is opened and a closed hæmostat thrust into the abscess. After opening the hæmostat and allowing the escape of thick foul-smelling pus, a rubber tube drain in which several side openings have been cut is introduced and held in position by a single suture.

Pelvic Abscess.—This is conveniently drained through the rectum or occasionally through the vagina. Spinal anæsthesia is of great assistance *as it ensures complete muscular relaxation*. *Immediately* before operation the bladder should be emptied by catheter.

Rectal drainage is carried out with the patient in the lithotomy position. A finger is passed into the rectum and the abscess wall palpated as it bulges into the front of the rectum from the recto-vesical pouch or the pouch of Douglas. A site is selected on the steep bulging face of the abscess (rather than at its apex) and a large closed hæmostat guided along the finger to the desired spot. The abscess is entered by exerting increasing pressure in an upward and forward direction. After the hæmostat has been opened, allowing the escape of copious foul pus, a rubber tube drain is inserted and held in place by a suture through the skin near the anal margin.

Posterior colpotomy (vaginal drainage) may be used in parous women. With the patient in the lithotomy position the cervix is identified and steadied by a volsellum. A small transverse incision is made in the posterior fornix immediately behind the cervix. A large closed hæmostat is thrust through into the abscess, care being taken that the approach lies in the midline since the large uterine and vaginal arteries lie on either side of the cervix. After the hæmostat has been opened a rubber tube drain is inserted and held in position by a suture through the vaginal vault.

Subphrenic Abscess.—A subphrenic abscess by reason of its deep situation is often difficult to diagnose. It is to be suspected when toxæmia persists and no abscess can be located elsewhere.

A subphrenic abscess is usually situated on the right side. Following widespread peritonitis the abscess may lie anteriorly between the diaphragm and the liver or posteriorly between the liver and diaphragm above and the kidney below, and the location of an abscess in these

Treatment.—The patient, as in other abdominal infections, is nursed sitting propped up on pillows. This position minimises abdominal movement by encouraging the thoracic type of respiration and may hinder the upward spread of infected fluids. Hot-water bags or hot moist applications applied to the tender area may be found soothing by the patient. No food is allowed by mouth for the first three or four days, since intestinal peristalsis is undesirable. Plain water is allowed but is not forced. Rectal salines are given if the tongue tends to be dry (6 or 8 oz. of warm normal saline four hourly or six hourly). No purgatives are given, and evacuant enemata are withheld. Sleep is encouraged by sedatives such as phenobarbitone (2 gr.) with aspirin (10 gr.); morphia and its derivatives are withheld, as they may mask *a change for the worse. Conservative treatment is abandoned in* favour of operation if the general condition of the patient becomes worse, if a two-hourly chart shows a rising pulse rate, if vomiting recurs, or if there is complaint of pain as distinct from tenderness on palpation.

This régime is freely modified to suit the requirements of the individual case. For example, if the patient has clearly surmounted the acute infection when first seen, it is sufficient to keep him under observation for a few days till every sign of disease is absent, withholding strong purgatives till resolution is complete.

R. A. J.

CHAPTER XXXVII

AFFECTIONS OF THE KIDNEY AND URETER

BEFORE advising any operation on the upper renal tract a thorough investigation must be carried out to determine the following points —

1 Has the patient two kidneys ?
2 What is the function of each kidney ?
3 If a stone is present what is its position and what is its effect on urinary secretion ?
4 If an infection is present what is the causal organism ?

STONES IN THE KIDNEY

Early operation should generally be advised For unilateral stones (the other kidney being healthy) there is a wide choice of procedure When the stone lies free in the renal pelvis it may be removed through a temporary incision in the pelvis (pyelolithotomy) When the stone lies in a calyx it may be removed through an incision in the kidney (nephrolithotomy) When there is a mild superadded infection drainage may also be necessary When the kidney is damaged beyond hope of recovery either by prolonged back pressure or by superadded infection it should be removed (nephrectomy) Nephrectomy is especially indicated in staphylococcal infections which are difficult to eradicate and prone to recurrent stone formation For bilateral stone the stone should first be removed from the less damaged kidney so that at a subsequent operation the second kidney may be treated by nephrectomy if this proves necessary There are exceptions to this rule Thus when the more damaged kidney is heavily infected the first step should be to drain or even remove it to obviate toxic absorption In the case of bilateral staghorn calculi there should be no haste to operate as this may add to the gravity of the prognosis

Pyelolithotomy —Where the stone lies free in the pelvis of the kidney the operation of pyelolithotomy is carried out The kidney is exposed and is held forwards in the anterior part of the wound, and the pelvis is dissected clean by blunt dissection An incision is then made into the posterior aspect of the pelvis the edges are held apart and the stone removed. The wound in the pelvis is closed by fine interrupted catgut stitches which should pick up the wall of the pelvis without penetrating it A drainage tube should be placed down to the wound in the pelvis in case of leakage

Where the stone is large or the pelvis is of intrarenal type so that

Treatment.—The patient, as in other abdominal infections, is nursed sitting propped up on pillows. This position minimises abdominal movement by encouraging the thoracic type of respiration and may hinder the upward spread of infected fluids. Hot-water bags or hot moist applications applied to the tender area may be found soothing by the patient. No food is allowed by mouth for the first three or four days since intestinal peristalsis is undesirable. Plain water is allowed but is not forced. Rectal salines are given if the tongue tends to be dry (6 or 8 oz. of warm normal saline four hourly or six hourly). No purgatives are given and evacuant enemata are withheld. Sleep is encouraged by sedatives such as phenobarbitone (2 gr.) with aspirin (10 gr.); morphia and its derivatives are withheld as they may mask a change for the worse. Conservative treatment is abandoned in favour of operation if the general condition of the patient becomes worse, if a two hourly chart shows a rising pulse-rate, if vomiting recurs, or if there is complaint of pain as distinct from tenderness on palpation.

This régime is freely modified to suit the requirements of the individual case. For example, if the patient has clearly surmounted the acute infection when first seen, it is sufficient to keep him under observation for a few days till every sign of disease is absent, withholding strong purgatives till resolution is complete.

R. A. J.

CHAPTER XXXVII

AFFECTIONS OF THE KIDNEY AND URETER

BEFORE advising any operation on the upper renal tract a thorough investigation must be carried out to determine the following points —

1 Has the patient two kidneys ?
2 What is the function of each kidney ?
3 If a stone is present what is its position and what is its effect on urinary secretion ?
4 If an infection is present what is the causal organism ?

STONES IN THE KIDNEY

Early operation should generally be advised For unilateral stones (the other kidney being healthy) there is a wide choice of procedure When the stone lies free in the renal pelvis it may be removed through a temporary incision in the pelvis (pyelolithotomy) When the stone lies in a calyx it may be removed through an incision in the kidney (nephrolithotomy) When there is a mild superadded infection drainage may also be necessary When the kidney is damaged beyond hope of recovery either by prolonged back pressure or by superadded infection it should be removed (nephrectomy) Nephrectomy is especially indicated in staphylococcal infections which are difficult to eradicate and prone to recurrent stone formation For bilateral stone the stone should first be removed from the less damaged kidney so that at a subsequent operation the second kidney may be treated by nephrectomy if this proves necessary There are exceptions to this rule Thus when the more damaged kidney is heavily infected the first step should be to drain or even remove it to obviate toxic absorption In the case of bilateral staghorn calculi there should be no haste to operate as this may add to the gravity of the prognosis

Pyelolithotomy —Where the stone lies free in the pelvis of the kidney the operation of pyelolithotomy is carried out The kidney is exposed and is held forwards in the anterior part of the wound and the pelvis is dissected clean by blunt dissection. An incision is then made into the posterior aspect of the pelvis the edges are held apart and the stone removed. The wound in the pelvis is closed by fine interrupted catgut stitches which should pick up the wall of the pelvis without penetrating it A drainage tube should be placed down to the wound in the pelvis in case of leakage

Where the stone is large or the pelvis is of intrarenal type so that

Treatment—The patient as in other abdominal infections is nursed sitting propped up on pillows This position minimises abdominal movement by encouraging the thoracic type of respiration and may hinder the upward spread of infected fluids Hot-water bags or hot moist applications applied to the tender area may be found soothing by the patient No food is allowed by mouth for the first three or four days since intestinal peristalsis is undesirable Plain water is allowed but is not forced Rectal salines are given if the tongue tends to be dry (6 or 8 oz of warm normal saline four hourly or six hourly) No purgatives are given and evacuant enemata are withheld Sleep is encouraged by sedatives such as phenobarbitone (2 gr) with aspirin (10 gr) morphia and its derivatives are withheld as they may mask a change for the worse Conservative treatment is abandoned in favour of operation if the general condition of the patient becomes worse if a two hourly chart shows a rising pulse-rate if vomiting recurs or if there is complaint of pain as distinct from tenderness on palpation

This régime is freely modified to suit the requirements of the individual case For example if the patient has clearly surmounted the acute infection when first seen it is sufficient to keep him under observation for a few days till every sign of disease is absent withholding strong purgatives till resolution is complete

R A J

CHAPTER XXXVII

AFFECTIONS OF THE KIDNEY AND URETER

BEFORE advising any operation on the upper renal tract a thorough investigation must be carried out to determine the following points :—

1. Has the patient two kidneys ?
2. What is the function of each kidney ?
3. If a stone is present, what is its position and what is its effect on urinary secretion ?
4. If an infection is present, what is the causal organism ?

STONES IN THE KIDNEY

Early operation should generally be advised. For unilateral stones (the other kidney being healthy) there is a wide choice of procedure. When the stone lies free in the renal pelvis it may be removed through a temporary incision in the pelvis (pyelolithotomy). When the stone lies in a calyx it may be removed through an incision in the kidney (nephrolithotomy). When there is a mild superadded infection, drainage may also be necessary. When the kidney is damaged beyond hope of recovery either by prolonged back pressure or by superadded infection it should be removed (nephrectomy). Nephrectomy is especially indicated in staphylococcal infections which are difficult to eradicate and prone to recurrent stone formation. For bilateral stone the stone should first be removed from the less damaged kidney, so that at a subsequent operation the second kidney may be treated by nephrectomy if this proves necessary. There are exceptions to this rule. Thus when the more damaged kidney is heavily infected the first step should be to drain or even remove it to obviate toxic absorption. In the case of bilateral staghorn calculi there should be no haste to operate, as this may add to the gravity of the prognosis.

Pyelolithotomy.—Where the stone lies free in the pelvis of the kidney the operation of pyelolithotomy is carried out. The kidney is exposed and is held forwards in the anterior part of the wound and the pelvis is dissected clean by blunt dissection. An incision is then made into the posterior aspect of the pelvis, the edges are held apart, and the stone removed. The wound in the pelvis is closed by fine interrupted catgut stitches which should pick up the wall of the pelvis without penetrating it. A drainage tube should be placed down to the wound in the pelvis in case of leakage.

Where the stone is large or the pelvis is of intrarenal type, so that

little of its posterior wall can be exposed an attempt should be made to dissect the kidney off the pelvis It is not safe to carry the incision in the pelvis across into the kidney substance for along the free edge of the kidney there runs the marginal vein from which troublesome hæmorrhage may occur If access cannot be gained in this way the kidney should be incised as described below Where exceptionally wide access is essential as for large staghorn calculi an incision on the inferior aspect of the pelvis may be continued up into the lower pole and the whole kidney split along a line just posterior to its greater curvature (pyelonephrolithotomy)

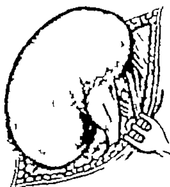


FIG 342

Pyelolithotomy The renal pelvis has been exposed from behind The site for incision is indicated

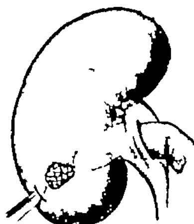


FIG. 343

Nephrolithotomy Cutting down upon a stone in a minor calyx, inaccessible from the pelvis.

Nephrolithotomy—When the stone lies incarcerated in a dilated calyx and cannot be reached from the pelvis the operation of nephrolithotomy is performed

The pelvis should first be opened by a small incision and the tip of the finger inserted to locate the stone The stone is projected towards the surface of the kidney and an incision is made directly over it through the kidney substance The stone is then extricated If it is dumb-bell shaped lying partly in a calyx and partly in the renal pelvis no force should be used lest severe hæmorrhage occur from vessels at the mouth of the calyx Instead the stone should be divided with bone-cutting forceps and the two parts removed one through the pelvis the other through the renal cortex

In all these operations great care must be taken to remove all fragments to prevent further stone formation and if possible an immediate check should be obtained by radiography before the wound is closed

Closure of the incision in the renal cortex is effected by deep catgut sutures tied without tension Hæmorrhage is often brisk during the operation, for while the kidney is held out at the wound the veins are liable to be compressed in the pedicle but it diminishes rapidly when

the kidney is allowed to fall into place If there is marked hydronephrosis or if the urine is heavily infected a drain may be inserted through the cortex into the dilated calyx In any case a drain should be placed down to the vicinity of the kidney to guard against leakage of urine

STONES IN THE URETER

Stones in the ureter tend to become impacted at the pelvi ureteral junction at the point where the ureter crosses the brim of the pelvis and at the entrance of the ureter into the bladder If the stone is of small size as seen in simple radiographs and if the renal function as shown by intravenous pyelography is but little impaired the treatment should be to encourage the passage of the stone by conservative methods In other cases operation should be performed

Conservative Treatment.—Fluids should be given in large quantities and antispasmodics are usually prescribed The patient should be encouraged to lead an active life In some cases descent of the stone is expedited by introducing a bougie into the ureter or by injecting oil or glycerin into the ureter through a ureteric catheter

When the stone is impacted at the lower end of the ureter and can be seen protruding from the mouth of the ureter the ureteric orifice may be dilated with ureteral bougies or the anterior lip of the orifice may be slit up with the diathermy electrode passed through the operating cystoscope

Operative Treatment.—When the stone is large when the renal function is impaired or when conservative treatment fails the stone should be removed

The ureter is exposed by the appropriate incision and lifted from its bed. The stone should be moved upwards from its point of impaction and removed through an incision made through healthy ureteric wall *The wound in the ureter heals more quickly in this way* To prevent the disimpacted stone from slipping up into the kidney the upper end of the ureter should be constricted temporarily by a piece of tape

The wound in the wall of the ureter is sutured with very fine catgut the stitch taking up the wall of the ureter only and not penetrating to the lumen The wound is drained

ANURIA

The causes of anuria include circulatory failure lesions of the kidneys and blockage of the ureters and may for convenience be classified as *prerenal renal* and *postrenal* The causal condition is often established and already under treatment when anuria develops as a complication When the cause is in doubt it is advisable to examine an X ray film for evidence of calculi and to draw off the residual urine by catheterising the bladder The specimen should be tested for albumin and examined microscopically for red blood cells casts and crystals

Prerenal Anuria.—The formation of urine by filtration through the renal glomeruli requires an adequate arterial blood pressure Oliguria becomes progressively more severe as the systolic pressure falls below 80 mm of mercury and anuria is generally absolute when

the pressure approaches 50 mm Fluid therapy is urgently required to avert death from circulatory failure Plasma transfusion (p 22) is of value not only after trauma and burns where plasma loss is known to have occurred but may also be life-saving in the circulatory failure of diabetic coma or cholera

Renal Anuria.—(a) *Nephritis* —Oliguria and occasionally anuria occur in the classical form of nephritis in the cortical renal necrosis of eclampsia and in poisoning by the heavy metals The diagnosis is based on the presence of œdema with a raised blood pressure and the finding of albumin red blood cells and casts in the urine Specific *treatment is not available decapsulation of the kidneys recommended* by some continental and American surgeons has never been widely advocated in Britain

(b) *Reflex Anuria* —Anuria without evidence of a pre-existing kidney lesion occasionally follows operations on the renal tract and rarely other operations Renal function is recovered spontaneously in most cases There is some evidence that recovery may be hastened by intravenous administration of crystalloid solutions which are not normally retained in the body such as sodium sulphate (1 litre of a 4 per cent solution) or sucrose (100 c c of a 50 per cent solu tion) The anuria which sometimes follows sudden decompression of the bladder in acute retention of urine may be of reflex type or may result from venous hæmorrhage into the kidney substance Renal function may be partially regained but nitrogenous excretion remains impaired and often leads to death from uræmia

(c) *Blockage of the renal tubules by crystals may occur in hæmolytic* states notably after transfusion with incompatible blood and in blackwater fever Hæmoglobin is present as such in the alkaline glomerular filtrate but as the urine becomes acid in its passage through the renal tubules is converted to acid hæmatin which crystallises out of solution as the urine becomes concentrated Complete blockage of the tubules and fatal anuria can be prevented in the majority of cases by keeping the reaction of the urine alkaline and maintaining a copious output of fluid Any preparation of alkali may be given pro vided the dosage is sufficient If the patient is able to drink, it is convenient to administer throughout each twenty four hour period 35 gm of potassium citrate dissolved in 2 litres of water and flavoured with fruit juice meat extract or coffee 8 gm of the first dose should be given at once to make the urine alkaline rapidly If the patient cannot drink it is convenient to administer daily by the intravenous *drip* method 600 c c of a 3 per cent solution of sodium citrate made up to 3 litres with isotonic glucose solution 150 c c of the first dose of citrate should be given at once by syringe Treatmen must be con tinued till hæmoglobinuria ... he recommend ... e is near *the limit of tolerance and* ... *must be int* ... or a few hours if symptoms of alkalosis ... he early sym ... lassitude giddiness and headache wit ... iting and m ... mp

(d) *Crush Syndrome* ... ure with ... r anuria developing ... *to five day* ... *ession of* ... has now been rep ... served in ... lties wh ... n plu

for some hours under fallen masonry The condition is fatal within a few days in about two thirds of the cases in the remainder recovery is heralded by a sudden polyuria The cause of the renal failure is variously attributed to toxic products of muscle breakdown and to blockage of the tubules by myohæmoglobin. The treatment tentatively recommended at the present time is to maintain a copious output of urine by efficient treatment of the initial surgical shock and thereafter by copious administration of fluid and to keep the reaction of the urine alkaline

Postrenal Anuria is usually due to impaction of a calculus in the ureter of the sole functioning kidney less often to bilateral impaction of calculi

CALCULOUS ANURIA

Calculous anuria is due to blockage of one ureter by stone the other kidney being absent or functionless The anuria generally

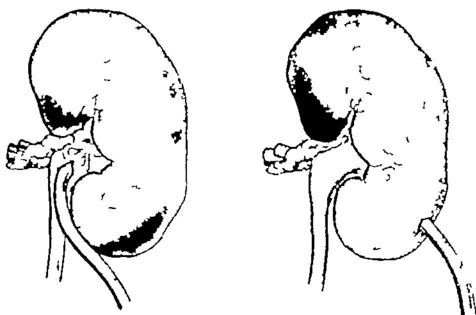


FIG 344

Pyelostomy showing catheter draining the renal pelvis.

Nephrostomy showing catheter draining the lower calyx of the kidney

supervenes after an attack of renal colic caused by impaction of the stone

The treatment should be prompt The first step is to locate the stone by simple radiography If possible a cystoscope should be passed and an endeavour made to introduce a ureteral catheter past the stone in order to drain the obstructed kidney If this is successful the catheter may be left *in situ* for forty-eight hours

Generally however immediate operation is required If the stone is within easy access it should be removed if not the kidney should be drained by nephrostomy

Nephrostomy—Drainage of the kidney may be undertaken for calculous anuria or calculous pyonephrosis It should be done only as an emergency procedure to save life for the drainage is difficult to control afterwards infection is apt to persist and the resultant fixation of the kidney adds to the difficulty of any subsequent operation that may be necessary The kidney is exposed and carefully cleared of perinephric fat If the pelvis is accessible it should be opened from the posterior aspect and drained If the pelvis is inaccessible an incision is made through the cortex of the kidney into the lowest calyx and a self retaining catheter introduced by this route

Anuria following Sulphonamide Administration—Several fatal cases of anuria have been recorded due to blockage of the renal pelvis and ureter by crystals of acetylsulphapyridine Blockage of the renal tubules does not appear to be an important feature The proportion of sulphapyridine excreted in the acetylated form varies from patient to patient and precipitation is favoured by massive doses with restriction of the fluid intake The early manifestations are hæmaturia with lumbar pain or occasionally renal colic and characteristic needle-shaped crystals are present in the urine The treatment is to stop at once the administration of sulphapyridine and to give copious amounts of fluid The administration of alkali is said to be of no value If excretion of urine is not resumed within a few hours catheterisation of the ureters with lavage to remove débris from the renal pelvis and ureters is highly effective

TREATMENT OF HYDRONEPHROSIS

The treatment of hydronephrosis varies according to the cause of the obstruction, the degree of renal damage and the condition of the other kidney

In unilateral calculous hydronephrosis if the renal function is not greatly impaired the stone should be removed as described above but if the kidney damage is severe nephrectomy should be performed providing that the other kidney is present and functioning adequately

In bilateral calculous hydronephrosis the considerations noted on p 675 should be taken into account

In hydronephrosis without obvious cause and in those cases where an abnormal artery is believed to be responsible the indications for treatment are less well defined If the dilatation is of slight or moderate degree and especially if bilateral improvement may be effected by periodic drainage and lavage of the renal pelvis a ureteral catheter being introduced and left *in situ* for a few hours at intervals of a few weeks If on the other hand the dilatation is of major degree and is unilateral, operation should generally be advised provided that the other kidney is present and functioning There is no consensus of opinion as to the type of operation to be carried out in such cases If an abnormal artery is found it is the practice of some surgeons to divide the artery and surrounding fibrous tissue with the object of relieving the pelvi ureteral junction from pressure but since this vessel is often an end artery supplying a considerable part of the lower pole

of the kidney the operation may lead to much renal atrophy In other cases it is sometimes advisable to perform a plastic procedure on the pelvi ureteral junction, or an anastomosis between the pelvis and the ureter but these procedures are rarely satisfactory in their end results For these reasons primary nephrectomy is usually the operation of choice

EXPOSURE OF THE KIDNEY

The kidney may be exposed through the lumbar region or through the abdomen The lumbar exposure is the one most often employed, but where there is a very large tumour or where it is necessary to expose both kidneys at the one operation the abdominal exposure may be used.



Fig 34

Position of the patient for operations on the kidney

The Lumbar Exposure — The patient lies on the sound side with a support from sandbags wedges or the bridge of the operating table placed half way between the costal margin and the iliac crest The underneath arm is pulled through from under the patient and the upper arm supported on a special arm rest The lower thigh is kept extended while the upper one is flexed and supported on sandbags

The incision starts 1 in below the angle between the last rib and the sacrospinalis muscle and is continued downwards and forwards a short distance above the iliac crest In the upper part of the wound the thin latissimus dorsi muscle is divided in the lower part the posterior edge of the external oblique muscle is cut through A second layer of muscles is now exposed the serratus posterior inferior above and the internal oblique below These are divided with care for immediately beneath them lie the twelfth thoracic nerve with its accompanying vessels and sometimes the eleventh thoracic nerve which must be preserved

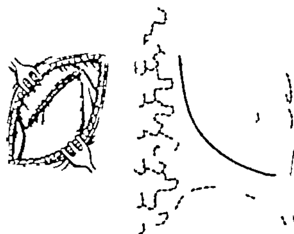


Fig 346

Exposure of the kidney *Right*—The incision. *Left*—Latissimus dorsi and part of external oblique muscles have been divided exposing perinephric fascia.

Posteriorly the edge of the sacrospinalis muscle is now exposed in front of this the perinephric fascia and fat and still further forward the peritoneum The peritoneal reflection is now mobilised forwards and the perinephric fascia is incised The kidney can now be palpated and is stripped of its fatty capsule by finger dissection Tough bands attached to the poles of the kidney

which may contain accessory arteries should be ligated before division. When separation has been completed the kidney can usually be brought out at the wound and inspected If necessary the exposure may be improved by retracting the last rib upwards after dividing the arcuate ligament which is felt as a tough band running downwards from the last rib under cover of the edge of the sacrospinalis

Closure of the wound is carried out in layers using continuous catgut stitches to pick up the muscles of which there are three layers in the anterior part of the wound and only two in the posterior part To allow the muscle edges to be approximated the sandbags or bridge should be removed from below the patient

The wound should always be drained for there is a large raw surface and a dead space into which oozing may occur

Wound herniation is not likely to occur provided the nerves are not divided The patient can be allowed out of bed twelve or fourteen days after operation

The Abdominal Exposure—The abdomen is opened by a paramedian incision extending from just below the costal margin to below the umbilicus and the small intestines are packed off to one side The colon is then exposed and drawn over towards the midline and the peritoneum along its lateral side incised As the colon is freed it carries its own vessels with it and the kidney is thus exposed in the retroperitoneal tissues

TECHNIQUE OF NEPHRECTOMY

When the kidney has been exposed *as described above* the peri nephric fat is dissected off the kidney and its pedicle by finger and gauze

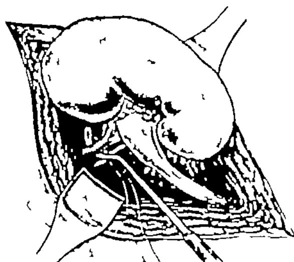


FIG 347
Nephrectomy showing ligature of renal artery

dissection The vessels are then exposed and if possible identified and ligated individually and divided The kidney still attached by its ureter is now drawn forwards and the ureter is freed downwards as

far as required, ligated and divided When the operation is performed for tuberculosis the greater part or the whole ureter should be removed

The main difficulty in nephrectomy is in dealing with the pedicle which especially on the right side is short If there has been a low grade infection, as is common in association with stones or tuberculosis the tissues round the pedicle are tough and adherent and can be separated only with difficulty In such circumstances the pedicle is carefully defined by blunt dissection and ligated *en masse* with no attempt to isolate individual vessels When there is much matting of the perinephric tissues subcapsular nephrectomy may be performed, the incision is made through the adherent tissues and true capsule

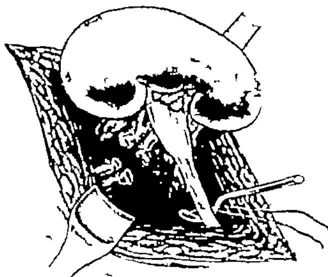


FIG 348
Nephrectomy vessels ligated individually and ligature being passed round ureter

down to the renal cortex and the kidney then freed within its capsule and removed

When the operation is performed for tumour of the kidney and the renal vein is involved in the growth there is apt to be much hæmorrhage from dilated vessels in the perinephric fat In such cases the pedicle should be exposed quickly and the renal artery compressed digitally to reduce the bleeding and enable the dissection to be completed.

In difficult cases during dissection of the pedicle the inferior vena cava has occasionally suffered damage This accident is less dangerous than might be thought The hæmorrhage can be controlled temporarily by packing and the wound, usually a linear tear can then be sought and closed by a continuous fine catgut stitch. If this proves impossible a hæmostat may be applied and left *in situ* for five or six days

EXPOSURE OF THE URETER

The ureter is almost invariably exposed by the extraperitoneal route the only notable exception being in the operation for implantation into the colon

Exposure of the upper third of the ureter is obtained through an incision which corresponds to the anterior part of the kidney incision and is deepened in the same way. The peritoneum is pushed forwards and the lower pole of the kidney identified. The ureter will be found just below the lower pole of the kidney and a little medial to it lying on the psoas muscle.

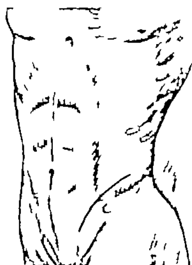


Fig 349
Incision for exposure of middle third of ureter

Exposure of the middle third of the ureter is obtained through an incision made over the iliac fossa running in the line of the fibres of the external oblique. The patient lies recumbent with the hip of the affected side elevated on a sandbag. The centre of the incision lies at the level of the anterior superior spine. The external oblique is split and the internal oblique and transverse muscles either split in the direction of their fibres as in the grid iron incision or preferably divided in the direction of the skin incision. The transversalis fascia is incised with care to avoid opening the peritoneal cavity and the peritoneum is then stripped medially. The ureter is reached opposite the tips of the transverse processes and is recognised by the fact that it remains attached to the peritoneum and is lifted up with it.

Exposure of the lower third of the ureter may be gained through a similar oblique incision which may be extended downwards through the rectus sheath or through a low paramedian incision. In either case the patient should be placed in the Trendelenburg position.

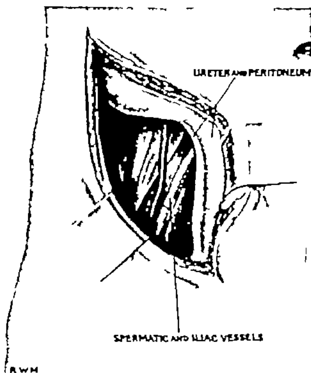


Fig 350
Exposure of middle third of right ureter which is lying medially adherent to the peritoneum.

When the paramedian incision is used the rectus is retracted and its posterior sheath and the transversalis fascia divided. The peritoneum is then stripped off working laterally posteriorly and then medially until the

CHAPTER XXXVIII

AFFECTIONS OF THE BLADDER AND URETHRA

USE OF CATHETERS AND BOUGIES

FOR male patients catheters of rubber gum elastic or metal are used. Rubber and metal instruments which are readily sterilised by boiling are preferable to gum elastic ones which can be sterilised only by prolonged immersion in antiseptic fluids For female patients soft rubber catheters and short straight glass catheters are used

General Technique—To prevent cystitis which is especially apt to develop in patients subjected to repeated catheterisation the most careful aseptic technique is necessary The surgeon should be washed and gloved as for a surgical operation In the male patient the whole penis should be thoroughly cleansed with soap and water with special attention to the glans and the deep aspect of the prepuce Sterile towels or a single towel perforated to accommodate the penis should be applied.

If catheterisation is to be repeated or if there is cystitis when the urine has been withdrawn the bladder should be washed out with a bland antiseptic solution such as boric lotion and finally 1 oz of 5 per cent argyrol may be left in the bladder Sulphanilamide therapy is useful also if cystitis should develop

To prevent catheter fever, a transient pyrexia with shivering or rigors which occasionally develops 5 gr of quinine sulphate or 10 gr of urotropin may be administered as a routine after catheterisation

Rubber Catheters.—In male patients the surgeon stands on the right of the patient holds the penis in the left hand and gently introduces the catheter—well lubricated with glycerin or a jelly lubricant —with his right hand Generally the catheter passes without difficulty until the bladder neck is reached The resistance at this point can usually be overcome by firm pressure or by rotating the catheter If this fails a rubber catheter of smaller size or a metal catheter must be used

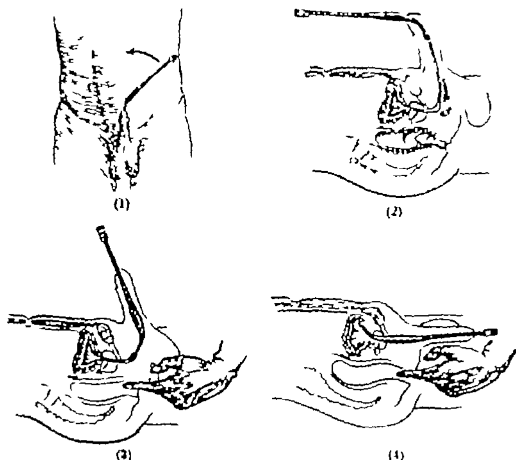
In female patients the surgeon should stand on the right side of the patient With his left hand he gently separates the labia to expose the urethral orifice which is situated an inch or so behind the clitoris The catheter is inserted gently and can usually be passed without difficulty

Metal Catheters and Bougies.—The method of passing bougies is described Metal catheters are introduced in the same way

It is customary to start with a size 9 12 bougie and if this fails

to pass, to try diminishing sizes until passage is effected This serves to locate the stricture and makes one familiar with the "feel" of the urethra before actual passage of the stricture is attempted In this way the risk of producing a false passage is minimised

The operator stands on the left side of the patient the penis being held in the left hand The bougie is introduced with the shank of the instrument held parallel with the inguinal ligament and its tip in contact with the roof of the urethra (Fig 351) When the tip has



(1) (2) (3) (4)

Fig 351

Introduction of bougies

(1) Bougie introduced with shank parallel to the inguinal ligament. (2) Traversing the penile urethra. (3) Finger in rectum used to guide point of bougie to prostatic urethra. (4) Shaft of bougie depressed between thighs until point reaches bladder

travelled towards the perineum the handle is swung round so that it lies in the midline close to the patient's abdomen Keeping the instrument in the midline the handle is swung up into the vertical position and then down between the patient's thighs, thus guiding the tip along the prostatic urethra into the bladder That the bladder has been reached is indicated by the fact that the instrument can be rotated freely through nearly 90 degrees

Throughout the manipulation every care must be taken not to make a false passage No force must be used the weight of the bougie backed by finger tip pressure on the handle should suffice to traverse the stricture Once the passage has been effected progressively larger

bougies are used but no attempt should be made to dilate the stricture fully at the first session

If the stricture cannot be passed with the ordinary bougies resort is had either to Miller s bougie or to filiform bougies Miller s bougie has a very fine point and is a dangerous instrument if not properly used It is passed in the same way as the ordinary bougie Its heavy handle serves to provide the *vis a tergo* and no extra force must be used

Filiform bougies are made of whalebone and are very fine Several of them are passed along the urethra until the stricture is reached. *First one and then another is gently pushed* until one of them is found to pass the stricture A second and a third are then introduced This will usually allow of the passage of a metal bougie

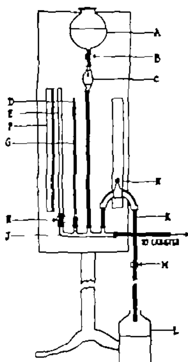


Fig 352

Tidal lavage apparatus. (Bell's modification of Munro s apparatus.)

Tidal Lavage of Bladder —Tidal lavage is useful when prolonged catheter drainage is required for example when the bladder is paralysed as a result of injury to the spinal cord (p 148) The apparatus shown in Fig 352 may be used Saline or boric lotion from the flask A runs through the drip connection C to the glass manifold J and thence to the catheter The drainage tube K leading to container L is supported by the rack N a few inches above the bladder level to give siphonage As the bladder fills the intracystic pressure rises until the fluid mounts the drainage tube when *the bladder is emptied by siphonage* The tube G with capillary orifice D acts as air inlet during siphonage The tube E and scale F form a cystometer for the estimation of intravesical pressure

EXPOSURE OF THE BLADDER AND CYSTOTOMY

This operation is indicated for the relief of acute retention where simpler methods fail for preliminary drainage in the two-stage removal of the prostate as a method of access for the removal of stones or tumours from the bladder and as a palliative procedure in malignant obstruction to the urinary outflow

When simple drainage is desired without wide exploration of the bladder the most satisfactory method is to introduce a self retaining catheter by means of a trocar and cannula using a local anaesthetic

The bladder should be distended so as to raise the peritoneal reflexion off the front of the bladder Where the bladder is already distended the operation is proceeded with but where the bladder is empty it should be distended by passing a rubber catheter and introducing boric lotion until the bladder can be felt above the pubis.

A small vertical midline incision is made about an inch above the symphysis and is deepened between the two rectus muscles which in this part of the abdominal wall lie in close contact with each other The index finger is introduced deeply just above the symphysis until the tense bladder wall is felt and then hooked upwards to separate the lower reflexion of the peritoneum and retract it out of the way

The trocar and cannula are now introduced The *instrument* is held in the palm of the hand with the index finger alongside and about an inch from the point and is plunged into the bladder

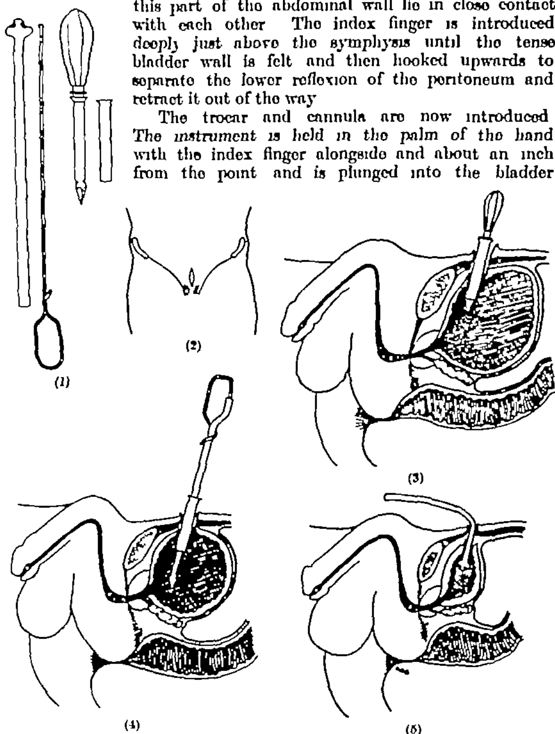


FIG 353

Drainage of bladder by self-retaining catheter.

(1) The instruments. (2) The incision. (3) Trocar and cannula *inserted* (4) Catheter stretched over introducer passed through cannula. (5) Cannula removed, introducer withdrawn.

boldly the finger serving to prevent its going in too far The trocar is withdrawn, the self retaining catheter stretched on its introducer is rapidly inserted and the cannula is then removed

Where a wider exposure of the bladder is required as for the removal of an enlarged prostate or stones, a general or spinal anæsthetic is given As a preliminary measure the bladder must be washed out and filled with boric lotion If cystitis is present lavage should be carried out if practicable for several days before operation

The incision may be made vertically in the midline above the symphysis pubis or transversely half way between the symphysis and the umbilicus The rectus muscles are exposed and separated thus exposing in the wound the reflection of the peritoneum above and the prevesical fascia below The prevesical fascia is then incised transversely in the lower part of the wound and the peritoneal reflection is stripped upwards. The bladder wall can be recognised by its interlacing muscle strands and by the network of veins lying over them A wide exposure of the bladder should be obtained extending up almost to the dome of the bladder

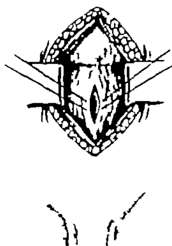


FIG 354
Suprapubic cystostomy Rectus abdominis muscles separated, peritoneal reflection dissected upwards, bladder wall opened between stay stitches.

The bladder wall is seized with two pairs of forceps one on each side of the midline At this stage the bladder may be emptied by a catheter passed along the urethra or a suction cannula introduced through a small incision in the bladder wall The opening in the bladder should be made as *high as possible lest it* retract behind the pubis as the bladder contracts

At the conclusion of the operation it is nearly always advisable to drain the bladder If much bleeding is expected for example after enucleation of the prostate some surgeons use Freyer's tube a short thick walled rubber tube with large lateral openings to prevent blocking by blood clot More commonly a self retaining catheter suffices

The tube is placed at the upper end of the wound so that the peritoneal reflection is prevented from returning to its position in front of the bladder In this way if it is necessary to enlarge or reopen the bladder wound subsequently the risk of opening the peritoneal cavity is minimised

The lower part of the bladder wound is closed with a continuous catgut stitch which includes all the coats of the viscus and is taken close up to the drainage tube to ensure a watertight closure The rectus muscles are approximated with interrupted stitches and the sheath restored either with an interrupted or a continuous stitch A small rubber dam drain is left in the lower part of the wound to drain the prevesical space and diminish the risk of pelvic cellulitis. Finally the skin wound is closed

Post-operative Care.—When cystostomy has been performed to relieve chronic urinary obstruction due for example to stricture or

prostatic enlargement the sudden relief of tension may lead to congestion of the kidneys with hæmorrhages into the renal tubules and so precipitate uræmia To prevent this uphill drainage should be used the drainage tube or catheter being led to a vessel a foot or so above the level of the bed Later the vessel is gradually lowered to effect a slower decompression

When on the other hand it is necessary to avoid distension of the bladder for example in rupture of the bladder or after enucleation of the prostate suction drainage is desirable For this purpose Bunsen's bottles may be used or preferably an electric suction motor

In all cases after bladder drainage the urinary secretion must be carefully measured and the amount charted If the secretion is inadequate the appropriate treatment must be carried out promptly (p 17)

When a cystostomy is to be maintained for a considerable time special care is required in its management to ensure that the tube drains well, that no leakage of urine occurs and that the ingress of infection is prevented

The self retaining catheter is conveniently fitted with a metal flange which can be incorporated in a body belt or corset When the patient is ambulant if the catheter is a tight fit in the abdominal wall it may be clamped or occluded with a wooden plug and the bladder emptied from time to time as the opportunity arises If leakage from the wound occurs when it is occluded the catheter may be left open and connected with a special rubber bottle fastened to the thigh. At night the catheter is connected to a rubber tube led to a bottle at the bedside

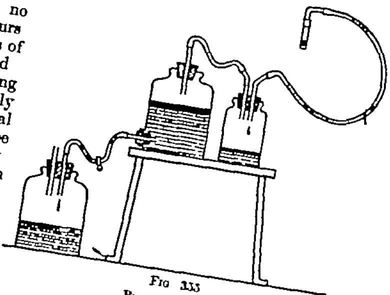


Fig 333
Bunsen's bottles.

To prevent infection the bladder should be washed out daily with a mild antiseptic fluid such as boric lotion After washing out 1 oz of 5 per cent argyrol may be instilled, the catheter being clipped for an hour thereafter Twice a week the bag and all tubing should be thoroughly cleansed and boiled A dilute solution of nitric acid is useful to dissolve encrustations of calcium phosphate The catheter should be removed every two weeks cleansed and sterilised and reintroduced Catheters of good quality should be used for with old ones the tip may come off during withdrawal and be left in the bladder

To change the catheter no anæsthetic is required Sometimes the

catheter can be removed by a firm steady pull but usually it is preferable first to stretch it over an introducer The new catheter is stretched over the introducer to obliterate its bulbous tip and is well lubricated A probe is passed down the track to demonstrate its direction and depth and the new catheter is then inserted to the *requisite depth before disengaging the introducer* *In a stout person* the depth may be 4 or 5 in When the catheter has been inserted properly it should be possible to move it in and out freely for a short distance its outward movement being limited by the bulbous portion impinging against the deep aspect of the bladder wound *Finally the bladder should be washed out through the catheter* this affords additional evidence that the catheter is properly in place for if its tip has not reached the bladder all fluid introduced will immediately leak out of the wound alongside the tube

Faulty drainage from the catheter with leakage alongside *is generally due to one of two causes* *Most commonly it is due to the* catheter having slipped partly out so that its orifice no longer lies within the bladder In other cases and especially when the catheter has been left *in situ* for a prolonged period without changing it is due to the deposit of phosphates in and around the tip of the tube The *treatment is to introduce a fresh catheter*

RUPTURE OF THE BLADDER

Rupture of the bladder a grave emergency may occur as a complication of fracture of the pelvis or rarely if the bladder is distended, as a result of a blow on the abdomen If the rupture is intraperitoneal the urine escapes into the peritoneal cavity and leads to severe toxæmia and to an insidious but grave form of peritonitis If the rupture is extraperitoneal the urine escapes into the pelvic cellular tissues, forming a deep-seated swelling which ascends into the abdominal wall from behind the pubes and gives rise to widespread cellulitis with much sloughing of the tissues

Where rupture of the bladder is suspected immediate steps must be taken to confirm the diagnosis and institute treatment A catheter should be passed at once Confirmation of the diagnosis is obtained by the fact that although the catheter enters the bladder without difficulty (in contrast to rupture of the urethra) only a little heavily blood-stained urine escapes while fluid allowed to flow into the bladder does not return

The treatment is to repair the injury without delay Under general or spinal anæsthesia the bladder is opened by the suprapubic route and its interior carefully examined For this purpose a special bladder retractor is useful and the patient should be tilted into the Trendelenburg position The tear is then closed by a continuous catgut stitch applied from the mucous aspect and with care to obtain a watertight closure A self retaining catheter or a *Freyer s* tube is then inserted and the opening in the bladder wall closed around it

When the rupture has been of intraperitoneal type no further step is required in an early case but in a late case where there has

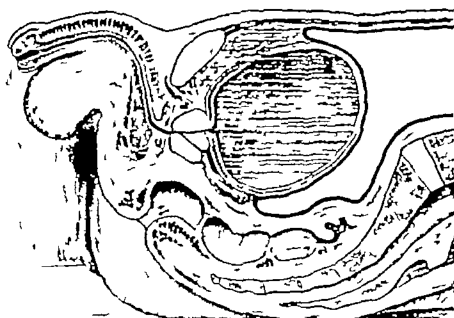


FIG 356
Extraperitoneal rupture of the bladder

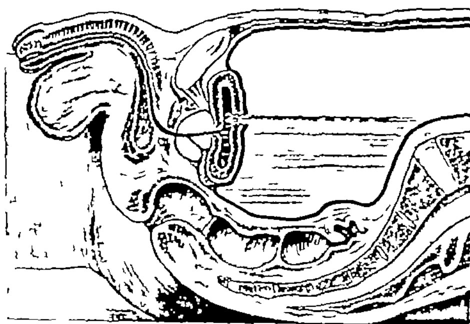


FIG 357
Intraperitoneal rupture of the bladder

been much flooding of the peritoneal cavity the peritoneum at the upper end of the suprapubic wound should be opened and a rubber dam drain inserted down to the pelvic floor

When the rupture has been of extraperitoneal type a tube should be inserted at the lower end of the wound to drain the pelvic cellular tissues in front of the neck of the bladder In late cases with wide extravasation further incisions should be made through the lower abdominal wall to either side and drains inserted Finally the perineum should be examined and if a boggy swelling is felt here drainage should be instituted to either side of the bulb of the urethra Prolonged drainage is necessary as large sloughs occur in the connective tissues and take a long time to separate Penicillin has a place in the treatment for it will limit the amount of sloughing and give earlier separation

RUPTURE OF THE URETHRA

The urethra may be injured as a complication of *fracture of the pelvis* and is then usually torn across at the point where it passes

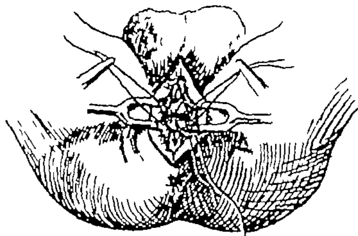


Fig 338
Rupture of urethra. The torn ends have been slit longitudinally to facilitate suturing

through the inferior fascia of the urogenital diaphragm Less often it is injured by a direct blow on the perineum sustained by falling astride a bar, and is then usually contused or ruptured in its bulbous portion The injury gives rise to bleeding from the urethral meatus and to pain associated with bruising in the midline of the perineum

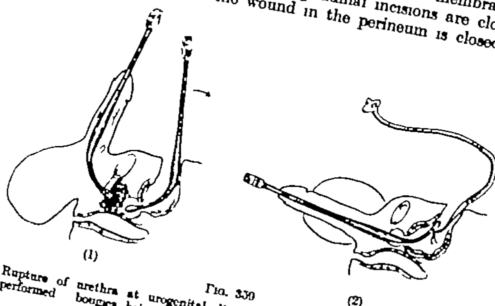
Where rupture of the urethra is suspected the patient should be instructed not to pass water An attempt should then be made to introduce a rubber catheter and if successful, the catheter should be tied in place for three days It should then be changed and the second catheter left in place for a similar period when normal micturition may be permitted Subsequently bougies should be passed at intervals to prevent the formation of a stricture

In the majority of cases the catheter will fail to traverse the site of rupture In such circumstances *immediate repair of the urethra* should be attempted Rarely if owing to associated injuries the patient is too gravely shocked for this to be practicable simple supra

pubic drainage of the bladder should be performed under local anaesthesia the repair being delayed until later Under no circumstances should all treatment be omitted for extravasation of urine will then occur and lead to widespread cellulitis

Repair of the rupture is performed under general or spinal anaesthesia The patient is placed in the lithotomy position and a bougie is inserted as far as the rupture A midline incision is made in the perineum about 3 in in length and extending back to about 1 in from the anus The incision is deepened on to the point of the bougie and thus the distal divided end of the urethra is identified A search is then made for the proximal end

To facilitate suture the two ends are incised longitudinally on their inferior aspect spread out and apposed as shown in Fig 3.8 Stay stitches are then inserted and interrupted fine catgut sutures are applied to draw the torn edges of the mucous membrane into accurate apposition Finally the longitudinal incisions are closed by a few catgut sutures and the wound in the perineum is closed with



(1) (2)

Fig. 330

Rupture of urethra at urogenital diaphragm. (1) Suprapubic cystostomy performed bougies being approximated to each other (2) Self retaining catheter being drawn retrograde along urethra.

drainage by rubber dam. The bougie is withdrawn and a rubber catheter is introduced from the meatus along the urethra to the bladder and left *in situ* for twelve to fourteen days

In some cases it is difficult to find the proximal torn end of the urethra In these circumstances the bladder should be opened by the suprapubic route and a bougie passed down the urethra from above The repair may then be performed as described above If the site of rupture is too deeply placed to allow this to be done the first bougie may be guided up to the bladder as shown in Fig 330 and a self retaining catheter attached to its tip then drawn down along the urethra where it is left *in situ* for twelve to fourteen days to keep the two ends of the urethra in alignment The suprapubic wound may then be closed with drainage to the prevesical space in case of leakage from the bladder

Whatever method is used bougies should be passed subsequently to prevent the formation of a stricture at first every few weeks later at progressively longer intervals

PERINEAL URINARY FISTULA

This commonly occurs as a complication of gonococcal stricture The fistula may form subsequent to a periurethral abscess which has burst or been incised or after operation for extravasation of urine into the tissues of the perineum Less often a fistula results from injury to the urethra or from necrosis of the urethral wall due to the impaction of a stone or foreign body

The fistula may open on the under side of the penis on the surface of the scrotum or in the perineum It soon acquires a mucosal lining, which becomes joined to the skin surface

Treatment is often rendered difficult by the presence of severe cystitis or kidney damage due to chronic retention of urine Preliminary drainage of the bladder therefore may be essential in any case, diversion of the stream of urine is valuable to facilitate healing of the fistula

If the stricture is permeable it should be dilated by bougies and the dilatation repeated at intervals The fistula may then close spontaneously If it persists it should be laid open and the edges pared so as to remove its lining of mucous membrane and the wound left open to heal by granulation

Where there has been much sloughing with consequent loss of tissue a plastic operation can sometimes be attempted utilising a strip of skin from the scrotum to close the defect

STRICTURE OF THE URETHRA

In most cases of urethral stricture whether due to gonorrhœa or to injury the treatment is by repeated dilatation The method of passing a bougie is described on p 686 On the first occasion care should be taken to avoid excessive dilatation lest the trauma initiate further scarring and contracture Generally it is wise to dilate through no more than three sizes of bougies at first The dilatation should be repeated every few weeks at first later the intervals may be lengthened to as much as six months or even a year

Rarely where the stricture *is a narrow localised one and tends* to contract rapidly after each dilatation, the affected part of the urethra may be excised The patient is placed in the lithotomy position and a bougie or staff is introduced into the urethra where it is held rigidly in the midline A midline incision is then made in the perineum down to the urethra at the site of stricture the affected segment is excised and the urethra reconstituted as described on p 695 If a long segment has been excised the two ends may be freed and mobilised for an inch or so to allow them to come together

Where a *stricture has led to acute retention of* urine an attempt should be made under general anæsthesia to pass a bougie If successful the stricture should be dilated sufficiently to allow the passage of a

small calibre metal catheter Further dilatation should be carried out at intervals thereafter

If the stricture should prove impermeable the bladder should be drained above the pubes Often after a week or so when the inflammatory reaction round the stricture has subsided the stricture becomes permeable and may be dilated by bougies After a few weeks the suprapubic tube may be removed and the bladder wound allowed to close

SIMPLE ENLARGEMENT OF THE PROSTATE

Patients with prostatic enlargement are elderly men Not uncommonly they are subject to bronchitis and present moderate or severe cardiovascular disease and frequently they suffer from various degrees of renal impairment Consequently the pre-operative assessment and preparation the choice of treatment and the after-care demand special attention and judgment

In the preliminary examination it is important to assess the general health of the patient giving particular consideration to the state of the heart and blood vessels In addition to the routine clinical examination the blood pressure should always be estimated and if a cardiovascular lesion is suspected an electrocardiogram may be useful.

Evidence of renal impairment should be sought both clinically and by laboratory examinations Such signs as headache anorexia dryness of the tongue and severe constipation are to be expected only in severe degrees of renal impairment but earlier indications may be found in the general appearance of the patient his nutrition and the state of the skin.

Routine tests of the urine for albumin sugar and casts should be supplemented by microscopic examination for pus cells and organisms The volume of urine secreted in twenty four hours and its specific gravity should be noted To estimate the degree of urinary obstruction a catheter should be inserted into the bladder immediately after micturition and any residual urine measured Of the renal function tests the blood urea or non protein nitrogen and the urea clearance test are generally regarded as the most informative

The choice of treatment must depend upon several factors particularly the severity of the symptoms the general health of the patient the functional state of the kidneys and the amount of obstruction to the urinary outflow It will be convenient to describe first the treatment of uncomplicated prostatic enlargement and later the modifications necessary when the condition is complicated by retention of urine

Uncomplicated Prostatic Enlargement

In this condition there is a choice of three possible lines of treatment—conservative measures perurethral resection, and prostatectomy—suprapubic or retropubic

Conservative measures are indicated in early cases or where the symptoms are not severe and the general health of the patient renders

operation inadvisable Prostatic hypertrophy is not necessarily progressive and moreover in some cases even a greatly enlarged prostate may cause few symptoms and give rise to little obstruction to the urinary outflow Such patients should be advised to lead a quiet life to avoid alcohol and to protect themselves from chills A simple diet should be advised excluding highly spiced and indigestible foods The bowels should be regulated carefully The condition should be reassessed every few months so that active treatment may be undertaken without delay if signs of urinary obstruction appear

Perurethral resection is now advised mainly for fibrosis of the prostate and as a palliative procedure in carcinoma In simple hypertrophy it is used only for patients whose general health is precarious and for such cases in expert hands it offers end results at least as satisfactory as those obtained by operation with the added advantages of lower mortality freedom from complications and speedier convalescence

Prostatectomy is the procedure of choice in most cases of simple hypertrophy

Provided that the patient s general condition is satisfactory and the renal function unimpaired the operation is performed in one stage In other cases the two-stage procedure is adopted the bladder being drained first and removal of the prostate postponed until a later stage

Prostatic Enlargement with Chronic Retention of Urine

In this type of case where a gradually increasing obstruction to the flow of urine has occurred the renal function may be greatly impaired and there is a grave risk of acute renal failure after operation Particularly is this the case in patients suffering from overflow incontinence from a chronically distended bladder Under such circumstances the immediate problem is to relieve the urinary obstruction removal of the prostate must be postponed until the renal function has been improved as far as possible

It is important to relieve the obstruction gradually for sudden decompression may cause acute congestion of the kidneys and lead to hæmorrhage and suppression of urine

If possible a catheter should be introduced and a few ounces of urine withdrawn every two hours or the catheter may be plugged and a hollow needle inserted through its wall to permit a slow drip of urine When the bladder has been emptied the catheter is left in place to give continuous drainage Lavage of the bladder is carried out daily and the catheter is changed every second day During the stage of decompression the patient should be encouraged to drink freely and a record of the fluid intake and output must be kept If the output falls or if signs of dehydration develop fluid should be given intravenously

After a week or two of catheter drainage when the immediate risk of renal failure has been overcome it is generally wise to drain the bladder suprapubically by means of a self retaining catheter thus reducing the risk of epididymitis and ascending urinary infection

which may follow prolonged use of the catheter. In some cases with comparatively little residual urine cystostomy may be carried out without previous decompression by catheter. In such circumstances gradual decompression may be achieved by leading the drainage tube to a receiver placed above the level of the bladder; after two or three days the receiver is gradually lowered so that the bladder empties completely.

The second stage of treatment may be carried out by perurethral resection or suprapubic prostatectomy; the second method is generally preferable for perurethral resection is not easy when the bladder has been drained.

The period of drainage required before embarking on the second stage varies from a few weeks to several months according to the functional response to the decompression. The second stage should be delayed until the general condition of the patient is improved as far as possible. Preferably the blood urea should be reduced to below 50 mg per cent; the twenty four hour urinary output should be not less than 40 oz. and its specific gravity 1010 or higher.

Prostatic Enlargement with Acute Retention of Urine

Acute retention may develop—as the result of a "chill" or temporary engorgement—at any stage in the process of prostatic enlargement. In planning the treatment not only relief of the retention but also the treatment of the enlarged prostate must be considered.

Where the acute retention is of short duration and the patient is in a good state of health immediate single stage prostatectomy may be carried out. This method has the advantage that infection of the bladder does not occur as a result of repeated catheterisation and suprapubic cystostomy. Where, on the other hand, the patient is in poor condition it is necessary to relieve the retention either by catheterisation which may need to be repeated or by the insertion of an indwelling catheter, the definitive treatment being delayed.

For relief of the acute retention such simple measures as a hot pack to the lower abdomen or immersion in a hot bath should be tried first. A large soap and water enema sometimes gives relief. Failing this a rubber catheter is passed; if this is unsuccessful a gum-elastic catheter and finally a large-curve metal catheter.

In cases where a catheter cannot be introduced, suprapubic cystostomy is necessary. Generally a self retaining catheter is introduced by means of a trocar and cannula. As a temporary expedient when facilities for operation are not available the bladder may be drained by a long needle such as a spinal needle inserted in the mesial plane immediately above the pubes.

Technique of Perurethral Resection.—Two types of perurethral resection apparatus are used. Each has a sheath resembling that of a cystoscope and fitted with an electric bulb, a telescope through which the prostate may be viewed and an arrangement of taps through which the bladder may be irrigated while the resection is in process. In the one type—the *fulguration resectoscope*—portions of the prostate are

resected by means of a loop electrode activated by fulguration (diathermy) high frequency alternating current In the other type—the *cold punch*—portions of the prostate ensnared through a slot in the outer sheath are punched out by a close-fitting sharp-edged obturator much in the same way as tickets are punched. The *fragments* are displaced into the bladder and subsequently evacuated by lavage By either method at a single session multiple fragments of the prostate can be removed totalling several grams in weight

Spinal anæsthesia is generally satisfactory During the resection *hæmorrhage occasions* difficulty by *obscuring* the view, but can be checked by continuous irrigation with hot saline solution Hæmorrhage may occur also during the twenty four hours after resection and if it is so copious as to cause clotting in the bladder it gives rise to retention of urine and much pain Accordingly as a routine a large-sized catheter is left *in situ* and the bladder is washed out at frequent intervals

Apart from hæmorrhage the procedure is remarkably free from trouble The patient can generally be allowed up after a few days thus avoiding the complications that result from prolonged decubitus in elderly people and the further convalescence is generally uneventful

Technique of Prostatectomy—*Pre-operative preparation* is essential in most cases, for the subjects of prostatic enlargement often are poor risk cases Preferably the patient should be kept at rest, though not entirely confined to bed for several days before operation on *a bland diet and with a high fluid* intake If the urine is infected a preliminary course of the appropriate chemotherapy should be given several days prior to operation

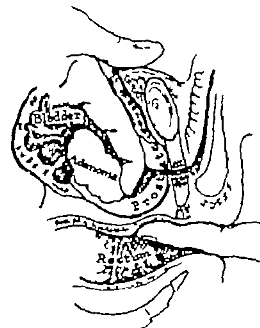


FIG 300
Diagram of the enucleation of the prostate

To *guard against the risk of* epididymitis—a common complication after prostatectomy—many surgeons practise preliminary vasoligation The vas deferens on each side *is palpated as it lies a short way* below the external inguinal ring and projected close under the scrotal skin Under local anæsthesia it is then exposed through a short incision separated from the other structures of the spermatic cord and ligated with catgut

The choice of anæsthetic for suprapubic prostatectomy is a matter for individual preference Spinal *anæsthesia* is useful as a routine but often an inhalational anæsthetic is satisfactory The patient should be placed in the inverted (Trendelenburg) position

The bladder is distended by introducing saline or boric lotion through a catheter which is clipped and left in position The bladder is then exposed and opened by the suprapubic route as described on p. 688

The prostate can now be palpated by a finger inserted into the bladder and both the prostate and the bladder wall should also be inspected after spreading the wound with a special retractor

Enucleation of the adenomatous mass is effected by the right index finger Since the access is deep many surgeons find it helpful to push the prostate upwards by means of the left index finger inserted into the rectum

The usual method is to insert the finger through the internal urinary meatus and thus to burst apart the encircling prostate which generally splits anteriorly The finger then feels for and opens up the line of cleavage between the adenoma and the false capsule of compressed

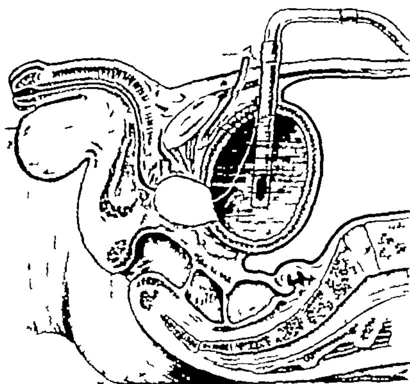


FIG 361

Illustration of bladder following suprapubic enucleation of the prostate showing Freyer s tube, drain in prevesical space and gauze pack in prostatic bed.

prostatic tissue and is swept round to either side until the adenoma is freed The prostatic urethra is torn across and the adenoma can then be lifted out from the bladder

After enucleation the prostatic bed should be smooth and any small residual adenomata and tags should be removed either by the finger or under direct vision after reintroducing the bladder retractor

The further steps are varied by different surgeons The simplest method which is generally quite effective is to leave the prostatic bed open and to close the wound in the bladder and abdominal wall leaving a drainage tube into the bladder and a strip of rubber dam to drain the prevesical space of Retzius For the bladder drain the original Freyer s tube may be used—a thick walled rubber tube of large diameter with wide fenestrations at its lower end—or a large-size

self retaining catheter The drain is connected with a suction apparatus (an electric pump or if preferred a system of Bunsen s bottles) and continuous suction applied to keep the bladder empty and free from blood clot

This method leaves the prostatic bed as a raw surface which must heal by granulation and may lead to fibrous stenosis *Harris s operation* was devised to overcome this *difficulty by reconstituting* the bladder flow A special boomerang ' needle is used Deep stitches are inserted through the postero lateral aspects of the rim of the prostatic bed to control hæmorrhage *and in the midline posteriorly* the mucosa of the bladder floor is stitched to the prostatic urethra while other stitches are inserted to obliterate the anterior part of the prostatic bed In favourable cases after this procedure the bladder wound may be closed completely a catheter being inserted along the urethra for a few days Harris s operation has given excellent results in the hands of expert urological surgeons provided that great care is exercised in the selection of suitable cases but it has not achieved wide usage

Recently Millin has devised the retropubic operation for removal of the prostate Exposure is made extravesically by separating the recti and opening up the prevesical space The prostate is exposed and after careful ligature of the veins of the prostatic plexus the capsule is incised horizontally Each lobe is then dissected out under vision A catheter is passed into the bladder and fixed there and the capsule of the prostate closed

The *post-operative care* after prostatectomy is of special importance In addition to the risk of cardiovascular and pulmonary complications such as may follow any operation on elderly poor risk patients there are the special dangers of renal failure hæmorrhage and infection

The patient must be propped up in bed and stimulants may be required If he has been accustomed to alcohol it should not be withheld at this stage Fluids should be given freely by the mouth by the rectum and if necessary by the intravenous route in *order to* maintain an adequate urinary excretion All urine collected must be measured and charted The volume of urine aimed at must vary *according to the extent of previous renal damage and in severe cases* a daily excretion of as much as 60 oz may be required to secure proper elimination of nitrogenous bodies Generally in the immediate post-*operative period the excretion falls short of this* but after two or three days the optimum level should be reached and maintained

Hæmorrhage from the prostatic bed is rarely formidable though in most cases an ooze persists for a few days If the blood loss is considerable the bladder should be washed out repeatedly with hot saline solution and blood transfusion may be required Rarely if the bleeding continues and especially if clotting occurs within the bladder it is necessary to open the wound completely and repack the prostatic bed

Infection of the wound and of the bladder leads to the risk of such complications as epididymitis and ascending urinary infection while in slighter degrees it is a common cause of delay in closure of the wound, and of later trouble from cystitis and stone formation Infection can be prevented only by the most rigorous aseptic technique If it develops

the treatment is on general lines by care of the wound repeated bladder lavage, and the appropriate chemotherapy

In the routine case the prevesical drain is removed on the third or fourth day Thereafter a Hamilton box may be strapped over the wound by frequently changed dressings

In favourable cases normal micturition is restored about fourteen days after operation and thereafter the suprapubic wound closes rapidly If micturition is delayed hexamine and sodium phosphate should be given in full doses to stimulate the normal reflex If this fails the urethra should be dilated gently with bougies This should not be done prematurely as it may stir up infection in the posterior urethra and predispose to epididymitis

FIBROUS PROSTATE

This type of prostate gives rise often to an insidious form of chronic urinary retention the patient presenting himself for treatment with advanced kidney damage

The assessment of the fitness of the patient is made in the same way as in simple prostatic hypertrophy If there is severe kidney damage preliminary drainage of the bladder will be required and this is most often done through an indwelling catheter If there is gross infection of the bladder in addition suprapubic drainage will be necessary

In mild cases temporary benefit can sometimes be obtained by periodic dilatation of the prostatic urethra by means of bougies More commonly resection of a portion of the fibrous ring is required This is now always carried out by the perurethral method (p 699) Suprapubic prostatectomy should never be attempted

CARCINOMA OF THE PROSTATE

The treatment of carcinoma of the prostate consists essentially of palliation, for it is only very rarely that complete extirpation of the growth is possible and up till the present time irradiation has given disappointing results

On the other hand encouraging results are obtained from the effects of hormones Dienœstrol in doses up to 45 mg per day will often produce relief of urinary symptoms and regression of the prostate and of secondary deposits in the bones

In association with this castration may also be effective in controlling the malignant growth

The treatment should be varied according to the degree of urinary retention

If as commonly occurs the growth gives rise to but little interference with micturition surgical treatment is not indicated. If it is causing retention of urine the most satisfactory treatment is to perform perurethral resection removing sufficient of the prostate to re-establish normal micturition If necessary the resection may be repeated

Suprapubic cystostomy is occasionally required but this operation

should be avoided or at least delayed as long as possible for although it relieves the urinary retention it does not benefit and may even aggravate the pain

STONES IN THE BLADDER

For stones in the bladder the choice of treatment lies between litholapaxy and suprapubic removal of the stones

In expert hands litholapaxy is preferable as it causes much less upset to the patient and a shorter period of disability Litholapaxy is not always practicable however and may be contraindicated In such cases suprapubic cystostomy should be performed

The contraindications to litholapaxy are —

1 Stone too large to be grasped by the instrument
2 Bladder incapable of dilatation sufficient to manipulate the instrument with safety
3 Stone adherent to bladder wall or incarcerated in a diverticulum
4 Presence of other lesions—such as tumour diverticulum prostatic hypertrophy or other obstruction at bladder neck—demanding cystostomy for their correction

A moderate degree of prostatic hypertrophy is not necessarily a contraindication to litholapaxy, provided that it is not so great as to interfere with the passage of the instrument and its manipulation within the bladder Removal of the stone by crushing may so diminish the prostatic congestion as to relieve all symptoms If not the prostate may be removed subsequently by periurethral resection

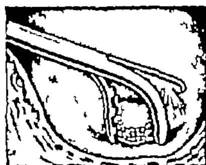


Fig. 362
Litholapaxy ; cystoscopic lithotrite in use.

Litholapaxy —If the stone is small, a cystoscopic lithotrite may be used by which the stone is gripped under vision and crushed If the stone is larger the older type of instrument must be used by which the manipulation is carried out blindly by sense of touch

A low spinal anaesthesia may be used The patient is placed in the lithotomy position and the head of the table tilted down about 30 degrees. The bladder is filled with a mild antiseptic solution such as boric lotion and the lithotrite passed The instrument is pushed in until the distal blade comes in contact with the posterior wall of the bladder with the handle of the instrument in the vertical position The blades are fully opened and then closed when the stone will be felt to be grasped The clutch in the handle is then engaged and with the stone lightly held the handle of the instrument is depressed and rotated to make sure that the bladder wall has not been gripped When one is satisfied that the instrument is free it is tightened and the stone is crushed If difficulty is experienced in grasping the stone the beak is turned slightly to one or other side The process of crushing is continued until no large fragments can be felt to be gripped

The lithotrite is removed and a large metal catheter passed This is connected to the evacuator which has been previously completely filled with water The rubber bulb is squeezed and allowed to expand

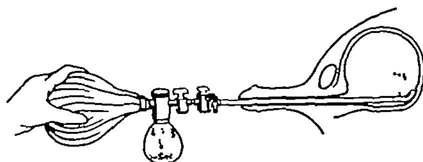


FIG. 303

Litholapaxy; the evacuator in use

when the fragments of stone will fall into the glass bulb When all the fragments have been removed in this way a cystoscope is passed and the bladder examined to make sure all of the stone has been removed.

DIVERTICULUM OF THE BLADDER

Diverticula of the bladder are most commonly false consisting of a herniation of the mucous membrane through a weak place in the muscle wall. Multiple small diverticula occur in severe degrees of urinary obstruction, but sometimes a single diverticulum forms even without any obstruction

Multiple diverticula usually require no other treatment than the removal of the cause of the obstruction Sometimes they contain stones which are removed through the suprapubic cystostomy wound after the necks of the sacs have been dilated with the tip of the finger

The single diverticulum usually opens into the bladder by a small opening near one of the ureteric orifices.

The diagnosis is made by cystoscopic examination and an estimate of the size of the diverticulum is made by noting how far a ureteric catheter can be passed in. Further information regarding its size is obtained from a cystogram The bladder is filled with an opaque fluid such as 12½ per cent sodium iodide solution and X rays taken in the anteroposterior the lateral, and the two oblique positions

The bladder is opened by the suprapubic route and a wide exposure obtained If the diverticulum is small it may be possible to turn it inside out by slipping the tip of the finger in and drawing the mucosa out When the apex is lying free in the bladder cavity the neck of the sac is ligated and the redundant part removed

Where the diverticulum is larger an incision is made through the mucous membrane around its mouth. The mucosa of the diverticulum is then seized at two or three places with artery forceps and gentle traction exerted. By dissecting with a blunt instrument the mucosa of the diverticulum is gradually freed and drawn into the bladder After its removal the wound in the muscular wall of the bladder is carefully closed with interrupted stitches and the mucosa reconstituted

with a fine continuous catgut stitch. The bladder is drained with a Freyer's tube

In the large diverticula which may even reach the size of a normal bladder a two-stage operation is embarked upon

The first stage consists of opening the bladder and closing the communication between the bladder and the diverticulum This is done by incising round the mouth of the diverticulum The muscular wall of the bladder is exposed and is carefully sutured. The mucosa of the bladder is then closed The bladder is drained with a Freyer's tube An opening is then made into the diverticulum, working extra peritoneally through the suprapubic wound and a large drainage tube inserted

When the patient's general health has been restored and when the daily washings from the diverticulum return clear, the second stage for the removal of the diverticulum is embarked on.

TUMOURS OF THE BLADDER

Papilloma and Papillary Carcinoma of the Bladder—Tumours of this class vary in malignancy from simple benign papilloma to carcinoma Moreover a tumour which presents the appearance of a simple papilloma may recur after local removal and tends in the course of time, and especially in elderly subjects to assume an invasive character

Accordingly these tumours should be looked upon as gradations in the same condition and be treated in the same way

These tumours occur in adults especially in elderly men, and they give rise to painless hæmaturia The primary tumour usually occurs in the bladder but rarely the primary may be in the renal pelvis, the papillomata in the bladder being secondary implants A clue to this condition is obtained from the presence of several separate tumours lying close to the ureteric orifice from noticing the passage of blood from the ureteric orifice at the cystoscopic examination, and from the history of passing long worm like clots formed in the ureter Final exclusion of the condition is made from pyelographic examination.

If the tumour is not larger than the size of a walnut it is treated by perurethral fulguration. If larger it is treated by removal through a suprapubic cystostomy wound the base of the tumour being carefully fulgurated with the button electrode There is a risk of implanting the tumour in the wound in the abdominal wall Care is therefore taken not to fragment the tumour After removal the bladder is washed out and the wound swabbed with 1 1 000 silver nitrate solution. The insertion of a radium implant into the bladder wall at the site of the base of the tumour is effective in preventing recurrence

Perurethral fulguration is best carried out under anæsthesia—general or low spinal. The negative electrode is strapped to the thigh or placed under the buttocks The cystoscope is passed and the electrode which is about the same size as a ureteral catheter brought into the view of the instrument Its tip is placed on the tumour and the current switched on. The tumour undergoes coagulation becomes pale in colour and then black. Treatment is continued until the whole

tumour has been dealt with, particularly its place of origin from the bladder wall. It is preferable to complete the treatment at one session

Two months later the bladder is re-examined to see that the tumour has been completely destroyed, and further re-examinations are made first at three-monthly and later at six monthly intervals for years lest recurrence take place

Carcinoma of the Bladder—This title includes the flat infiltrating type of growth as well as invading papillary growths

The treatment of these tumours is difficult for they occur commonly near the base of the bladder, spread widely and often involve the ureteric orifices and the internal urinary meatus

When the tumour is small and is situated on the side wall of the bladder it may be removed. When it is more advanced and is situated on the base irradiation may delay its growth and afford some relief.

In the later stages when the tumour has spread to the extravesical tissues severe pain is a feature and this is not relieved by suprapubic drainage nor even by presacral neurectomy

Partial Cystectomy—This operation is carried out where the tumour is small and situated away from the base of the bladder The bladder is exposed by the suprapubic route and the peritoneum stripped well off its upper surface It is then opened and the tumour identified Dissection is then carried down outside the bladder until the affected part lies free The tumour along with an area of healthy wall around it is excised. The wound in the bladder wall is repaired by closing first the muscular coat and then the mucosa A Freyer's drainage tube is left in the bladder If the ureter is involved in the growth its lower end may be removed along with the affected segment of bladder wall. The cut end of the ureter is then implanted into the bladder at a convenient level where it will lie freely and without tension

Total Cystectomy—In cases where the bladder is widely involved by papillary carcinoma and in certain cases of ulcerative carcinoma complete removal of the bladder may be undertaken.

The first stage consists of the implantation of the ureters into the colon to be followed by the removal of the bladder when the first operation has been completely recovered from.

The operation must be carried out in two or three stages First the ureters are divided a short distance above the bladder and implanted into the pelvic colon. Sometimes both ureters may be transplanted at one session, but in poor risk cases to obviate the risk of renal failure, each should be transplanted separately Removal of the bladder is carried out a few weeks later It is an operation of considerable magnitude and is not often practicable Description of the steps of the operation is beyond the scope of this book.

W A. D A.

with a fine continuous catgut stitch The bladder is drained with a Freyer's tube.

In the large diverticula which may even reach the size of a normal bladder a two-stage operation is embarked upon

The first stage consists of opening the bladder and closing the communication between the bladder and the diverticulum. This is done by incising round the mouth of the diverticulum. The muscular wall of the bladder is exposed and is carefully sutured. The mucosa of the bladder is then closed. The bladder is drained with a Freyer's tube An opening is then made into the diverticulum working extraperitoneally through the suprapubic wound, and a large drainage tube inserted

When the patient's general health has been restored and when the daily washings from the diverticulum return clear the second stage for the removal of the diverticulum is embarked on.

TUMOURS OF THE BLADDER

Papilloma and Papillary Carcinoma of the Bladder—Tumours of this class vary in malignancy from simple benign papilloma to carcinoma Moreover a tumour which presents the appearance of a simple papilloma may recur after local removal and tends in the course of time and especially in elderly subjects to assume an invasive character

Accordingly these tumours should be looked upon as gradations in the same condition and be treated in the same way

These tumours occur in adults, especially in elderly men, and they give rise to painless hæmaturia The primary tumour usually occurs in the bladder but rarely the primary may be in the renal pelvis the papillomata in the bladder being secondary implants. A clue to this condition is obtained from the presence of several separate tumours lying close to the ureteric orifice from noticing the passage of blood from the ureteric orifice at the cystoscopic examination, and from the history of passing long worm like clots formed in the ureter Final exclusion of the condition is made from pyelographic examination.

If the tumour is not larger than the size of a walnut it is treated by perurethral fulguration If larger it is treated by removal through a suprapubic cystostomy wound the base of the tumour being carefully fulgurated with the button electrode There is a risk of implanting the tumour in the wound in the abdominal wall Care is therefore taken not to fragment the tumour After removal the bladder is washed out and the wound swabbed with 1 1 000 silver nitrate solution The insertion of a radium implant into the bladder wall at the site of the base of the tumour is effective in preventing recurrence

Perurethral fulguration is best carried out under anæsthesia—general or low spinal. The negative electrode is strapped to the thigh or placed under the buttocks The cystoscope is passed and the electrode which is about the same size as a ureteral catheter brought into the view of the instrument Its tip is placed on the tumour and the current switched on The tumour undergoes coagulation becomes pale in colour and then black. Treatment is continued until the whole

tumour has been dealt with, particularly its place of origin from the bladder wall. It is preferable to complete the treatment at one session

Two months later the bladder is re-examined to see that the tumour has been completely destroyed and further re-examinations are made first at three-monthly and later at six monthly intervals for years lest recurrence take place

Carcinoma of the Bladder—This title includes the flat infiltrating type of growth as well as invading papillary growths

The treatment of these tumours is difficult, for they occur commonly near the base of the bladder spread widely and often involve the ureteric orifices and the internal urinary meatus

When the tumour is small and is situated on the side wall of the bladder it may be removed When it is more advanced and is situated on the base irradiation may delay its growth and afford some relief.

In the later stages when the tumour has spread to the extravesical tissues severe pain is a feature and this is not relieved by suprapubic drainage nor even by presacral neurectomy

Partial Cystectomy—This operation is carried out where the tumour is small and situated away from the base of the bladder The bladder is exposed by the suprapubic route and the peritoneum stripped well off its upper surface It is then opened and the tumour identified Dissection is then carried down outside the bladder until the affected part lies free The tumour along with an area of healthy wall around it is excised The wound in the bladder wall is repaired by closing first the muscular coat and then the mucosa A Freyer s drainage tube is left in the bladder If the ureter is involved in the growth its lower end may be removed along with the affected segment of bladder wall. The cut end of the ureter is then implanted into the bladder at a convenient level where it will lie freely and without tension

Total Cystectomy—In cases where the bladder is widely involved by papillary carcinoma and in certain cases of ulcerative carcinoma complete removal of the bladder may be undertaken.

The first stage consists of the implantation of the ureters into the colon to be followed by the removal of the bladder when the first operation has been completely recovered from.

The operation must be carried out in two or three stages First the ureters are divided a short distance above the bladder and implanted into the pelvic colon. Sometimes both ureters may be transplanted at one session but in poor risk cases, to obviate the risk of renal failure, each should be transplanted separately Removal of the bladder is carried out a few weeks later It is an operation of considerable magnitude and is not often practicable Description of the steps of the operation is beyond the scope of this book. W A. D A.

CHAPTER XXXIX

AFFECTIONS OF THE MALE GENITAL TRACT

PHIMOSIS AND PARAPHIMOSIS

IN infancy phimosis must be distinguished from so-called adhesions of the prepuce In the normal infant and for some years after birth the prepuce can be retracted with difficulty owing to the presence of a layer of epithelial cellular débris which lightly binds the prepuce to the glans penis. *These adhesions can be separated by sweeping a* fine probe gently round between the prepuce and the glans Phimosis may then be diagnosed if the prepuce still cannot be retracted, or if after retraction it cannot readily be drawn forwards. In such cases if the prepuce is long circumcision should be performed if it is short the dorsal slit procedure is preferable

Circumcision in Infants.—The operation is indicated for phimosis and for ritualistic and social reasons Circumcision should not be per formed in infants when there is ammoniacal napkin irritation for meatal ulceration is apt to occur causing severe dysuria In such infants the napkins should be changed frequently boiled and soaked in saturated boric solution before drying while boric powder should be dusted on the tender parts

Circumcision is contraindicated where a hæmorrhagic tendency is suspected and in hypospadias when the skin of the prepuce must be retained for use in the appropriate plastic operation (p 712)

If the infant's general condition is satisfactory circumcision is best carried out in the first ten days of life At this age no anæsthesia is required At later ages open ether is the anæsthetic of choice It must be emphasised that partial anæsthesia constitutes the main danger of the operation owing to the risk of sudden reflex circulatory failure when the clamp is applied. This tendency is most marked under partial chloroform anæsthesia and the whiff of chloroform must *therefore be avoided at all costs*

The prepuce and the surrounding skin are prepared by washing with soap and water the skin being thereafter dried and cleansed with ether The preputial sac should not be interfered with as the smegma which it contains is quite innocuous

The first step is to apply a clamp to the prepuce A long narrow hæmostat is generally used but a straight bone-cutting forceps is preferable for it is easier to apply accurately and by its crushing action diminishes capillary oozing Since the crush is linear the incision may be made distal to the clamp for very little tissue is damaged and there is no risk of necrosis.

The clamp should be applied obliquely parallel to the coronal sulcus, and it should be applied at such a level that when the skin retracts its cut edge lies on or just below the sulcus On the dorsal aspect the correct level is about one-third of the way from the corona to the tip of the glans

The application of the clamp is the most important step of the operation for if too much skin is removed the whole penis may be flayed, while if too little is removed—and that in a circular, cuff like manner—the phimosis will recur

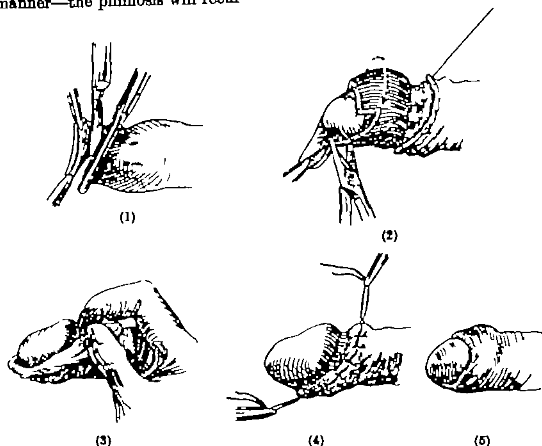


FIG 364

Circumcision.

(1) Clamp applied and prepuce incised. (2) Skin retracted, mucosal cuff being trimmed. (3) Mucosa retracted to expose glans. (4) Sutures applied. (5) The end-result.

The usual method is to seize the tip of the prepuce and draw it down before applying the clamp A preferable way however is to apply the clamp at first gently so as to grip the skin alone as it lies at rest on the glans and then slide it distally as it is tightened, taking care not to exert full pressure until the tip of the glans is safely passed

The prepuce is removed with a sharp knife cutting against the clamp—on its proximal side if a hæmostat is used on its distal side in the case of a bone-cutting forceps

When the divided skin retracts a cuff of mucosa still partly covers and may adhere to the glans It should be separated cleanly up to the coronal sinus any embedded smegma being removed. If necessary a short slit may be made in the mucosal cuff in the midline dorsally so that it can be turned back smoothly

Complete hæmostasis must now be effected to prevent the risk of a hæmatoma Generally three small arteries require ligation, one on each dorsolateral aspect and one near the frenum.

The margins of skin and mucosa are then sutured together proximal to the coronal sulcus using interrupted stitches of fine catgut mounted on eyeless needles

A dressing is then applied Some surgeons use a narrow strip of ribbon gauze soaked in friar s balsam winding it round the corona but leaving the urethral orifice exposed The balsam hardens and forms a waterproof dressing and splint which may be left in place for four or five days Great care must be taken however to apply the gauze loosely lest the penis be strangled. An alternative method in more general use is to apply ribbon gauze soaked in vaseline It can be removed the following day and replaced by a simple vaseline pad which is renewed each time the napkin is soiled

The complication most to be feared is hæmorrhage Prolonged and *serious hæmorrhage may result from hæmophilia or from the bleeding* dyscrasias of infancy In the former blood transfusion effectively arrests the hæmorrhage in the latter vitamin K often is effective.

More commonly bleeding results from carelessness in hæmostasis *A hæmatoma forms and within a few hours the penis may be lost* in a massive subcutaneous infiltration of blood. The treatment here is to give a general anæsthetic sponge away the blood ligate the bleeding point and resuture

Sepsis is rarely a complication apart from a mild infection which clears up in a day or two Occasionally however a severe or even fatal streptococcal erysipelas has occurred doubtless as a result of droplet infection at operation To guard against such a risk full aseptic theatre technique should be followed.

Circumcision in Adults.—General anæsthesia is usually preferable but local anæsthesia may be used if desired novocaine being injected as a subcutaneous infiltration encircling the penis at the level of the corona

An operative technique similar to that used in infants may be employed. Often however it is preferable first to split the foreskin in the midline dorsally and then to trim away as much as desired Hæmostasis must be secured with particular care and accurate stitching *is advisable*

After operation luminal or other sedative should be given for a few days to prevent erection which is painful and apt to cause severe hæmorrhage

Dorsal Slit Operation.—This procedure is useful in infants with a short prepuce and in adults particularly where operation is required in cases of balanitis

The prepuce is divided exactly in the midline (to minimise hæmor rhage) preferably by means of blunt pointed scissors Care must be taken when introducing the scissor blade under the prepuce to avoid entering the urethral meatus This vertical incision is then converted into a transverse wound by drawing the two sides of the prepuce apart, and stitched in this axis by three or four catgut sutures

It is important that the incision in the skin should stop short of the coronal sulcus while that in the mucosa should not go farther than the middle of the glans In this way the split foreskin deformity is avoided

Paraphimosis.—In the majority of cases the retracted prepuce may be drawn forwards by manipulation after the œdematous glans has been firmly compressed for a few minutes in a swab wrung out of adrenaline and novocaine In more severe cases it is better to give a general anæsthetic gas and oxygen or pentothal, under which, if reduction by manipulation fails, it will be achieved by making a series of snips with a pair of fine scissors exactly in the dorsal midline of the strangulating prepuce *One attack is an indication for circumcision after all œdema has settled down* C F W I

EPISPADIAS

In this condition the dorsal surface of the urethra has failed to develop and the urethra opens on the dorsal surface of the penis at

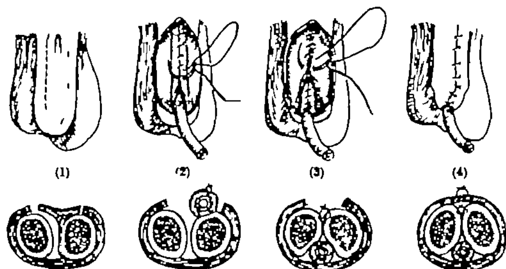


FIG 365

Epispadias.

(1) Longitudinal incisions made. Corpora cavernosa (below) separated. (2) Flaps elevated and sutured to form new urethra. (3) New urethra displaced ventrally; corpora cavernosa being sutured. (4) Operation completed.

some point proximal to its normal exit either on the shaft of the penis or at its base Distal to this opening the urethra may be represented by a longitudinal groove on the dorsal surface of the penis Where the deformity is gross *ectopia vesicæ* usually coexists This is by far the commonest variety of dorsal deformity simple epispadias of itself being much less common than hypospadias

Before operative repair is considered it is necessary first to see that there is control of the bladder *i e.* to see that the sphincter is normally developed

The most suitable age for operative interference is generally regarded as between six and twelve years

As a preliminary to any operative repair a suprapubic cystostomy is performed

Two longitudinal incisions are made parallel to and on either side of the urethral groove encircling the abnormal urethral orifice proximally and reaching the tip of the penis distally By this means two narrow flaps are elevated and sutured to one another around a catheter to form the new urethra The corpora cavernosa are separated and the new urethra is pushed through between them, where it lies in its normal position in the ventral part of the penis The skin edges on the dorsum of the penis are sutured and the catheter is left in for several days (see Fig 365)

McIndoe found that this operation tended to leave the patient *with a short urethra and* he now prefers to convert the epispadias into hypospadias which he repairs by the method he has designed.

Where there is ectopia vesicæ the ureters are transplanted into the pelvic colon The transplantation of each ureter is done as a separate operation with an interval of two to three weeks between each stage Later the bladder extroversion is excised to prevent the development of carcinoma

HYPOSPADIAS

In hypospadias it is the ventral urethral wall which has failed to develop and in addition the penis is short and curved ventrally on itself

Three degrees of this malformation may be seen as the urethra *opens on the glans penis the penis or in the perineum*

The glandular type may require no treatment other than a simple circumcision This type of case may be mistaken for a complete atresia of urethra unless a careful search is made at the base of the glands for the tiny meatal orifice

The penile and perineal types may be treated by various plastic methods In mild cases the urethra may be dissected out and pulled *forwards or passed through a tunnel in the glans penis*

As a rule however the deformity is more extensive and in addition the penis is recurved towards the scrotum Several plastic operations have been devised all of which have one feature in common their complexity

The following are the main features of the Ombrédanne type of operation *The age at which the first stage should* be undertaken is generally agreed to be about three years though this decision must be influenced by the size of the organ In cases of hypogenitalia it may be considered necessary to precede operation by endocrine therapy

First the penile recurvature is overcome by a transverse incision just distal to the urethral orifice the wound being sutured vertically The penis is maintained in the straightened position by suturing it to the abdominal wall with a swab intervening

After at least three months the second stage is attempted in which a flap of skin from the ventral aspect of the base of the penis is turned distally to replace the missing ventral wall of the terminal part of the

urethra (see Fig 366 (4) and (5)) The raw outer surface of this flap is covered by a skin flap taken from the prepuce (see Fig 366 (6))

At the present time an increasing number of these cases are being treated by the plastic surgeons either by the use of pedicle skin flaps or by a tubular skin graft which is passed through the length of the penis on a specially adapted trocha and cannula First at two years of age the penile recurvature is corrected Then when the child is seven or eight urethral reconstruction is carried out by passing a Thiersch graft wrapped round a length of gum elastic catheter through

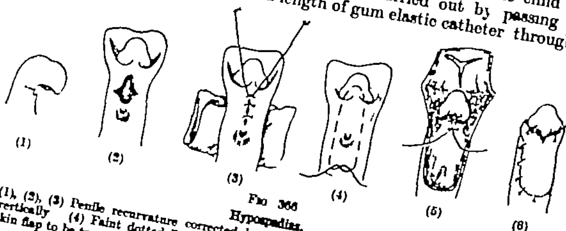


Fig 366

Hypospadias.

(1), (2), (3) Penile recurvature corrected by transverse incision, opened out and sutured vertically (4) Faint dotted lines indicate sites for incisions. Suture inserted to anchor skin flap to be turned down as ventral wall of urethra. (5) Prepuce flap elevated and split to accommodate glans. (6) Operation completed.

the cannula The new urethra is constantly held stretched by special gum elastic dilators for six months when after external urethrostomy the posterior end of the new urethra is anastomosed to the hypospadiac meatus

UNDESCENDED TESTICLE

In examining a patient in whom one suspects the presence of an ndescended testicle it is essential to carry out the examination under the ideal conditions of a warm room warm examining hands and a suitably covered couch It is sometimes useful for the examiner to take a friendly part in the undressing of a child Ideally the examination should be made with the patient in a warm bath Examination in a cold room with cold hands and on a cold leather couch will cause some degree of retraction even in the normal child.

The testicle may be in one of four positions (1) Scrotal and normally developed (2) extra-canalicular i e distal to the inguinal canal (3) canalicular (4) abdominal.

The extra-canalicular testicle which is normal in size and deviated to one of the ectopic sites such as the inguinal or femoral regions requires purely surgical treatment Opinion varies as to the treatment of the extra-canalicular testicle which is delayed in its descent Bishop advises endocrine therapy particularly in bilateral cases, and he prefers to have caused descent by the age of nine

The canalicular testicle is one which has failed to develop fully and will therefore require hormone therapy Bishop found that as

many as 75 per cent of these cases responded to treatment If descent does not occur surgical intervention is called for If such a case of canalicular testicle is seen well past the age of puberty the testicle being atrophied, the problem then arises should the testicle be left alone, placed in the scrotom or removed because of the small but undoubted danger of malignant change Under the circumstances it is perhaps right that the patient or his relatives should be told that three out of every hundred undescended testicles undergo malignant change and the choice of treatment left to them

The abdominal testicle is probably rarer than was formerly imagined. These should be treated by endocrine therapy if necessary for as long as six or nine months if this fails operation should be carried out by skilled and careful hands

Hormone treatment should not be given before the age of seven or eight but may of course be given up to the age of puberty

The most potent method of hormone treatment has been found to be chorionic gonadotrophin which is obtained from the urine of preg nant women and is given in doses of 500 international units every three to seven days if necessary for eight weeks. In ideal cases the testicle may descend into the scrotum in four weeks These injections must be carefully supervised as they may cause rapid development of the secondary sex characteristics

Operative treatment is indicated where injection treatment has failed, or is unsuitable or where there is a co-existent and troublesome hernia

At operation if the testicle can be mobilised sufficiently it is placed in the scrotum and fixed there (orchidopexy) If not some surgeons recommend a two-stage operation the testicle being brought down as far as possible and left there following operation endocrine therapy is given and six to nine months later the testicle is placed in the scrotum at a second operation If it is obvious that the testicle will never reach the scrotum it may be either placed within the abdomen or removed. Abdominal replacement is preferred to orchidectomy if the other testicle is also undescended for the gland is thus protected from injury while such internal secretory activity as it possesses is conserved. If the other testicle is normal orchidectomy is preferable to obviate the risk of malignant disease

Orchidopexy—The inguinal canal is opened by a short oblique incision as for inguinal hernia (see Fig 260) and the spermatic cord is dissected out If a hernial sac is present it is separated and dealt with

The testis must now be mobilised sufficiently to be placed without *tension in the scrotum.* *Its anchorage in the undescended position* is due not to shortness of the vas deferens but to shortness of the vascular pedicle and in particular the connective and lymphatic tissues accom panying the internal spermatic artery This can be overcome by freeing the vessels of adhesions up to and even beyond the internal ring Further lengthening may be obtained by blunt dissection with the finger in the retroperitoneal space so as to mobilise the posterior parietal peritoneum to which the spermatic vessels are adherent thus giving them a more direct and therefore shorter course to run from

their point of origin In performing this step it is often found that a fan-shaped band of fibrous tissue containing the spermatic vessels runs from the cord up into the retroperitoneal region, this band should be carefully divided and the vessels freed. On no account should the spermatic artery be sacrificed to facilitate the descent as atrophy of the testis will inevitably occur the artery to the vas being insufficient to maintain the testicular blood supply

A finger is now passed into the poorly developed scrotum and this is stretched to accommodate the testis which should reach it without tension



FIG 367

Orchidopexy Testis anchored by silkworm gut fixed to skin of thigh.

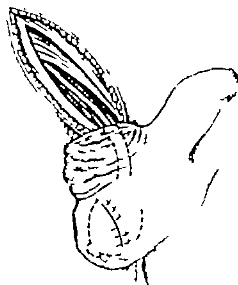


FIG. 368

Trans-septal orchidopexy

To prevent subsequent retraction of the testis most surgeons insist that it must be anchored in place by one or other of the following methods —

1 By inserting a silkworm gut stitch which penetrates the tunica albuginea, passes through the foot of the scrotum and is fixed to the skin of the thigh the stitch being retained for three weeks

2 By passing the testis through a small opening in the septum to the opposite side of the scrotum (trans-septal orchidopexy)

3 By passing the testis (its vascular pedicle being preserved) through an incision in the foot of the scrotum and embedding it in the fat of the femoral triangle the scrotal wound being sutured to the edge of the skin incision in the thigh (Keetley Torek operation) Three months later when all danger of retraction is past the embedded testis is restored to the scrotum (see Figs 367 369)

Gilbert has shown that an operation to bring the testicle into the scrotum still leaves the danger diminished but nevertheless present of malignant change and for this reason he *suggests that all these* cases should be followed up for ten or twelve years

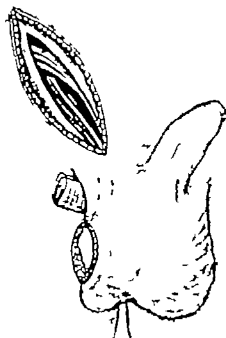


Fig 360
Orchidopexy Keetley Torek operation.

It should be remarked that the whole basis for the operative treatment of undescended testis lies in the belief that the development of the gland to full maturity is enhanced by restoring it to the scrotum This belief rests on no secure foundation and in practice the results of orchidopexy are disappointing Even if the testis remains in its scrotal bed—and retraction to the groin is common whatever type of operation is *used—it often fails to develop* and may even become more atrophic especially if it has been deprived of its blood supply by rough *handling* or *by* anchorage under tension

HYDROCELE

The treatment of hydrocele may be by aspiration injection or operation

Aspiration —This method is valuable as a palliative in elderly and frail patients and as a preliminary step in a large hydrocele to facilitate examination of the testis

Before *tapping* it is important to ascertain the position of the testicle by palpation and trans illumination to avoid injuring it with the needle

The scrotum is cleansed by soap and water If the testis is in its *normal position behind the sac the puncture is made antero-inferiorly* A suitable point is chosen clear of vessels and infiltrated with a small quantity of 2 per cent novocaine With the scrotum firmly held in the left hand a trocar and cannula is inserted into the hydrocele in an upward and backward direction (*Fig 370*) *Once* the sac is empty the cannula is withdrawn and the opening is sealed with gauze and collodion The scrotum must then be supported by a suspensory bandage to reduce the risk of hæmorrhage into the sac (hæmatocele)

Injection —This consists in tapping a hydrocele and then injecting some sclerosing fluid such as 5 c c 5 per cent sodium morrhuate This method is uncertain in its results and is liable to be followed by suppuration.

Operation —In nearly all cases this is by far the most satisfactory

line of treatment The hydrocele may be approached by an inguinal or a scrotal incision

In the inguinal approach a 3-in incision is made over the external ring in the direction of the spermatic cord The external pudic vessels are usually divided and require to be secured and ligated The assistant now applies upward pressure to the affected side of the scrotum thus presenting in the wound part of the anterior surface of the hydrocele with its coverings These coverings are incised and the tunica vaginalis is exposed To prevent flooding of the operation field fluid is withdrawn by trocar and cannula The sac can now be freed by gauze dissection and brought out in the wound At the lower pole sharp dissection may be required to divide adhesions between the sac the coverings and the scrotum on the completion of which the testis and tunica vaginalis should lie free in the wound If sharp dissection has been necessary care should be taken to see that all bleeding points are picked up and tied off.

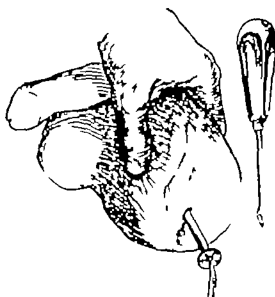


FIG. 370
Tapping a hydrocele.

In the further treatment of the hydrocele two main methods may be used The sac may be split down its anterior wall the redundant

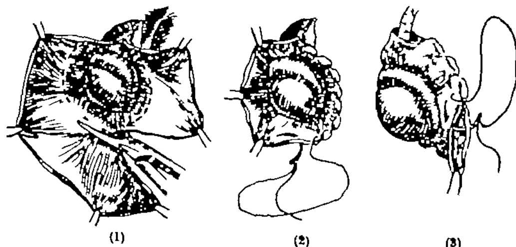


FIG 371
Hydrocele.
(1) Excising redundant tunica vaginalis. (2) Continuous hæmostatic stitch to cut edge of tunica. (3) Tunica vaginalis everted and stitched behind testis.

portion of the sac having been cut away it is then everted and the edges of the sac are sutured together behind the testis or the greater part of the sac may be excised In this latter method hæmorrhage

from the free edge of the sac may be troublesome and must be prevented by ligating all bleeding points or by applying a continuous suture (Fig 371 (2))

The testicle is now returned to the scrotum, care being taken to replace it without torsion of the cord and the wound is closed. To prevent post-operative oozing into the capacious scrotum the part must be enveloped in wool and supported on a pad of wool or a bridge of adhesive strapping fixed across the thighs Despite every care a scrotal hæmatoma may develop and to avoid this many surgeons insert a small drain by a stab incision into the most dependent part of the scrotum the drain being removed in two or three days

In the scrotal approach a 2 in incision is made in the median raphé on the anterior aspect of the scrotum the coverings of the tunica vaginalis of the affected side are then incised and dissected off and the operation proceeded with as detailed above Contrary to general belief the scrotal skin heals readily and well

Encysted hydrocele of the cord is a swelling containing opalescent fluid situated in an isolated rudiment of the processus vaginalis above the level of the testis. It is best treated by simple excision.

Hæmatocele, or hæmatoma of the tunica vaginalis is often due to the penetration of a vein in tapping a hydrocele but may result from other forms of trauma Active treatment is demanded to obviate pain and to prevent atrophy of the testis If seen immediately after the onset the blood may be removed by aspiration Later the clot must be evacuated by open operation. In late cases where the testis is atrophic it and the tunica vaginalis should be removed

SPERMATOCELE

A spermatocele is a cystic swelling filled with opalescent milky fluid containing spermatozoa and usually situated behind the upper pole of the testis, *i.e.* between the caput epididymis and the testis It may be single and of moderate size or multiple and small

In the elderly patient simple tapping may suffice although recurrence is likely As in hydrocele tapping should not be undertaken until the position of the testis is certainly ascertained. In hydrocele the testis is behind the cystic swelling in spermatocele the testis is below and in front

In the younger patient spermatocele should be treated by operation It is exposed by the usual incision over the external ring and excised

VARICOCELE

Varicocele is usually found in young men and tends to diminish or disappear spontaneously Except in neurotic subjects it generally gives rise to no symptoms or to only slight discomfort and active treatment is rarely required Operation was formerly advised as a routine in cases of varicocele and was imposed at one time on candidates desirous of entering the armed forces It is now rarely necessary

In most cases it suffices to reassure the patient, to advise general toning up measures, and to prescribe a suspensory bandage Operation will be necessary only where the varicocele is large and painful or disabling

The operation has two main principles first to divide some three-quarters of the pampiniform plexus and second to raise the testicle to a higher level within the scrotum. The plexus may be exposed at the external ring or within the inguinal canal The latter approach is preferable

Operation—The inguinal canal is opened by the usual incision the cord is exposed and its coverings divided The vas is isolated with a few veins from the rest of the cord The spermatic artery is sought and preserved The rest of the veins are now collected together freed upwards to the deep ring and downwards to the upper pole of the testis, ligated at these two levels by transfixing ligatures and the intervening mass of veins removed

To elevate the testis the two ligatures may be tied together or the lower ligature may be stitched to the external abdominal ring The wound is closed and a suspensory bandage is worn The patient is allowed up after the third or fourth day

Complications of this operation arise from faulty estimation of the amount of venous plexus to be removed thus if too many veins are tied a hydrocele may develop or the testis may subsequently undergo fibrosis and atrophy On the other hand inadequate removal will lead to recurrence

TREATMENT OF TUBERCULOUS EPIDIDYMITIS

Since genital tuberculosis is so often part of a more wide spread disease affecting urinary pulmonary, or skeletal systems it follows that no decision in regard to treatment should be made until these systems have been fully investigated Borthwick found that 70 per cent of tuberculous epididymitis had renal tuberculosis as a primary disease

According to Reid treatment should be based on the fundamental conception that tuberculosis is a general disease with local manifestations and that operation if performed should on no account be an isolated therapeutic measure but should be carefully timed, planned and carried out preferably by those skilled in genito-urinary tuberculosis It follows therefore that all cases of tuberculous epididymitis whether discovered as an isolated lesion or one of several tuberculous lesions, should be nursed in a sanatorium

If other serious lesion is present decide which is the most threatening to life and treat it In the absence of co-existent disease the initial treatment should be one of rest in hygienic surroundings with fresh air and good food. The scrotum should be supported by a suspensory bandage or an elastoplast bridge across the thighs If a sinus is present it should be curetted and dressed with aseptic precautions.

After some weeks or months when the acute inflammatory reactions have subsided, the general condition is good and the disease has become

localised to primary nodules of decreasing tenderness more thorough surgical intervention should be considered

Epididymectomy —A 2 in incision is made over the external ring and in many of the cases the incision will require to be extended on to the scrotum to enclose and excise the tuberculous fistula which is present in over 40 per cent of cases The testicle is pushed up into the wound and its coverings are incised The epididymis is then separated from the back of the testicle starting inferiorly at the cauda epididymidis and continuing the dissection upwards the vas is freed from the spermatic cord up to a point just inside the external ring where it is divided after ligation and the injection of a little pure carbolic Great care must be taken to preserve the internal spermatic artery to ensure the blood supply of the testicle

To reduce the risk of the spread of infection to the other side—a common occurrence—most surgeons advise the removal of a segment of the vas on the healthy side

Tuberculin therapy may be given as a post-operative measure

Young of Baltimore believing that tuberculous epididymitis is secondary to disease of the seminal vesicles recommended an extensive operation to remove the epididymis vas and vesicles along with a part or the whole of the prostate However perfect this operation appears to be it carries a considerable operative mortality and as a result it has not been generally adopted

TUMOURS OF THE TESTIS

Since tumours of the testis metastasise early especially to the lumbar glands early treatment is necessary to achieve cure These lumbar glands if enlarged, will be found on abdominal examination if the patient s knees are well flexed and the abdomen relaxed.

The general surgical practice is to advise orchidectomy in all early cases and also in late cases where the tumour threatens to fungate. Since testicular tumours especially seminoma, are highly radiosensitive X ray therapy should be advised post-operatively in all cases and may even be considered justifiable in the early cases as an alternative to surgery

Orchidectomy —An incision similar to that advised for inguinal hernia is used namely just above and parallel to the inguinal ligament If the testicular tumour is large and requires a wide exposure the incision will be continued downwards on to the upper part of the scrotum The cord is picked up and followed to as high a level as possible where it is ligated by means of a transfixing ligature The cord is divided between this ligature and a clamp With the forceps on the lower end as a retractor the distal cord and testis are pulled upon and the coverings of the testis are divided along with any attachments it may have to the scrotum. In this way the testis is freed and removed. The wound is examined for any bleeding points and closed with care to avoid inversion of the wound edges. This is especially liable to happen if the scrotum has been opened

Where the tumour is already invading the scrotum, the incision is

modified so as to sweep round both sides of the involved area which is removed in continuity with the tumour

A more extensive operation has been devised to combine removal in continuity of the tumour with the lymphatics and lumbar glands This extensive operative procedure naturally carries a higher operative mortality

The tumour is reached by the usual incision, which is enlarged upwards in a manner somewhat similar to the extraperitoneal approach to the lower end of the ureter The incision curves about ½ in above the anterior superior spine and then upwards to the costal margin at the level of the tenth rib The lymphatics are found in the retroperitoneal fascia extending between the renal veins above and the bifurcation of the aorta below Efficient removal demands the excision of all fascia and lymphatics covering the iliacus and psoas muscles of the related side the spermatic vessels being ligatured at their point of origin and removed

Even following this extensive procedure treatment should be completed with a course of deep X ray therapy

EPITHELIOMA OF PENIS

The treatment of epithelioma of the penis will depend largely on the extent and nature of the growth to be dealt with An early growth and growths which are ulcerative or cauliflower in type (and therefore as a rule free from much infiltration) are best treated by radium or X ray therapy the general principles of which are discussed in the chapter on radiotherapy Even where the inguinal glands are slightly enlarged this method is satisfactory for often the enlargement is due to sepsis

Where the growth is nodular in type and therefore infiltrating deeply or where the growth is extensively infected radiotherapy is ineffective and early operative interference is to be preferred

The nature of the operation depends on the situation and extent of the growth If the growth is situated at the corona (the commonest site) a partial amputation is adequate

A piece of rubber tubing tied at the base of the penis acts as an efficient tourniquet The course of the urethra is indicated by the passage of a metal bougie as far into the urethra as the tourniquet will allow A short flap of skin is raised from the ventral or under surface of the penis well clear of the disease. The *corpus spongiosum* and the contained urethra are thus exposed and divided about ¾ in distal to the base of the ventral flap A more generous flap is now mapped out on the dorsal and lateral surfaces of the penis sufficiently long to permit of the passage of the new urethral orifice through its surface and to meet the ventral flap without tension This flap is now dissected up to its base at which point the corpora cavernosa penis are amputated.

All vessels are now picked up and ligated the tourniquet is released, and any further bleeding is arrested

A small incision is made in the dorsal flap to take the urethra,

which is passed through this opening and slit up a little way on either side before being sutured to the edges of the opening The skin flaps are now loosely sutured to one another (see Fig 372)

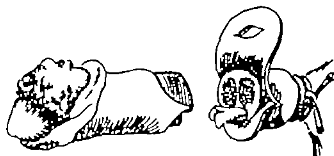


Fig 372
Partial amputation of penis. Long dorsal skin flap split to accommodate urethra.

A stricture is liable to develop at the new meatus and this should be guarded against by the periodic passage of bougies

If the growth is more extensive or more proximal in situation a complete amputation is necessary A bougie is passed into the urethra. A racket incision passing around the base of the penis is carried back

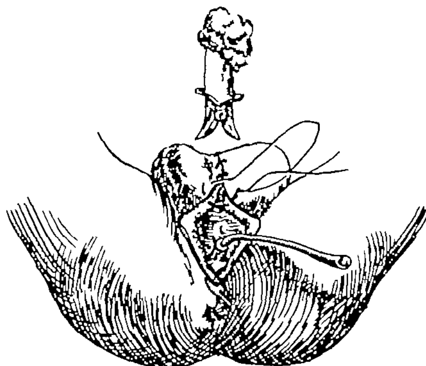


Fig 373
Complete amputation of penis. Urethra divided in bulbous portion and brought out at perineum.

wards in the midline so as to split the scrotum completely The corpus spongiosum is dissected out and divided leaving sufficient length of a stump to bring out of the scrotal wound The wound around the base of the penis is now deepened and the suspensory ligament divided following which the crura are detached by blunt dissection from the

pubis and ischium all vessels being caught as they are divided The urethra is now slit up and stitched to the edges of the scrotal wound to open into the perineum the rest of the scrotal wound being closed around a small drain (see Fig 373)

Some surgeons prefer to remove the scrotum and both testicles when a complete amputation of the penis is necessary

EPITHELIOMA OF SCROTUM

In the scrotum unless the growth is of large size the redundant skin gives an adequate margin of healthy tissue to permit of wide excision while owing to the laxity of the tissues it is difficult to apply radium either in the form of a plaque or in needles in such a way as to give uniform dosage For these reasons surgical removal of the primary growth is to be preferred Often the glands in one or both groins are involved, and require treatment on the lines indicated below

MALIGNANT GLANDS IN THE GROIN

Enlargement of the inguinal glands from malignant disease either in the penis or the scrotum is best treated by excision unless the glands are adherent or the patient is considered unfit for the fairly severe operation that dissection of the groin glands entails If operation is considered unsuitable X ray therapy may give a satisfactory result

As a rule a bilateral excision at the time of the original operation is the method preferred, but this depends on the extent of the involvement The operation is carried out through a vertical or flap incision The entire femoral triangle is cleared of its glands up to the inguinal ligament and if necessary the dissection is continued up the external iliac vessels It should be borne in mind that wounds in the groin heal slowly and necrosis of the skin may occur especially where the skin edges have been undermined.

K. F

REFERENCES

BISHOP P M. F (1945). "The Management of Undescended Testicle. *Guy's Hosp. Reports,* **94,** 1 and 2, 12.

BORTHWICK, W M. (1945). Tuberculosis of the Male Genital Tract. *Glasgow med J* **26,** No. 144 172.

McINDOE, A. H. (1937). "An Operation for the Cure of Adult Hypospadias. *Brit. med J.* **1,** 385.

McINDOE, A. H. (1948) "Deformities of the Male Urethra. *Brit. J Plastic Surg.,* **1,** 29

QUINBY W C. (1945). "Undescended Testis. *New Engl J Med.,* **232,** No 24, 701

REID R (1947). "Tuberculous Epididymo-orchitis. *Med. Press* **5629** 241.

YOUNG H. H. (1946). "Practice of Urology

CHAPTER XL

REHABILITATION

SINCE the last war much progress has been made in the science and art of rehabilitation Previously there was a tendency to concentrate attention on the primary treatment of the sick and injured and but little interest was taken in the subsequent progress and well being of the patient The effects of illness and injury on a patient s ability to work were ignored and often no steps were taken to secure employment for the permanently disabled The social problems which are inseparable from disease and injury were seldom recognised nor the importance of psychological treatment in the restoration of physical and mental fitness

Rehabilitation as practised to-day aims at restoring the patient not only to health but also to working capacity and social circum stance It demands a planned programme of treatment which com mences on the day of injury and terminates when the patient has been restored to his maximum degree of physical fitness and economic independence The treatment can be conveniently divided into two stages that of medical rehabilitation which is primarily concerned *with the treatment of the physical injury or illness and industrial* rehabilitation in which the patient is returned to his former occupa tion or trained for a new vocation Continuity of treatment is essential and steady progress to full recovery can only be achieved if the surgeon himself is prepared to lead and inspire every member of his team collaborate with industry and study the personality and social back ground of his patients

Rehabilitation finds its greatest field of usefulness in persons disabled through injury especially industrial workers and the descrip- tion of rehabilitation methods in this chapter applies particularly to this type of case In modified form however they may be adapted to many general surgical cases

MEDICAL REHABILITATION

The keystone of rehabilitation is prompt and efficient treatment Following most surgical procedures a period of rest *is desirable for* nothing delays recovery more than disregard of sound surgical principles Too often however the period of rest is prolonged far beyond what is necessary or desirable with the result that mental

and physical deterioration supervene and the patient's recovery is unduly delayed

Physiotherapy.—Throughout the whole period of rehabilitation the emphasis should be on active exercise rather than the purely passive forms of physiotherapy. Massage, radiant heat, diathermy, and paraffin wax baths are, however, valuable preliminaries to active exercise in the treatment of stiff and painful joints. They relieve pain and muscle spasm and facilitate active movements.

Once the acute phase of the disease or injury is over, simple exercises are instituted. They are performed in bed at regular intervals throughout the day under the direction of the physiotherapist. Exercises, if properly chosen and regulated according to the needs of the individual patient, not only hasten convalescence but reduce post-operative morbidity. The exercises may be designed to prevent muscle wasting and to retain the mobility of the joints of an injured limb, or to prevent general physical deterioration in those patients whose disability necessitates a long stay in hospital. Every effort should be made to instil an atmosphere of optimism and cheerfulness into the ward. The inclusion of team games as part of the bed exercises stimulates competition and relieves a tendency to monotony. The personality of the physiotherapist carrying out ward exercises is of vital importance, since patients with long term disabilities need constant and enthusiastic encouragement.

Remedial Exercises.—When the patient is ambulatory, remedial exercises of a more strenuous character are introduced. In these exercises there are four basic principles:—

1. The exercises must be smooth and rhythmical so that the joints and muscles are not subjected to unexpected strains.
2. The exercises must be progressive in strength and duration until the effort demanded corresponds to that of the patient's ordinary occupation.
3. Each joint should be put through the maximum range of *active* movement.
4. Restoration of muscle power is more important to manual workers than joint mobility. A joint which is not under full muscular control is prone to strains which in themselves will cause further muscle wasting.

Muscles may be developed by the use of resisted movements, resistance being provided by gravity or a weight and pulley circuit. Gravity resisted exercises are of value in the treatment of spinal injuries. The exercise is commenced with the hands clasped behind the back and the effort required is increased by raising the arms until they are fully extended above the head (Fig. 57). A weight and pulley circuit can be adapted for exercising almost all groups of muscles in the limbs and spine (Fig. 374). The exercises are performed slowly and smoothly and the joint is put through the maximum range of painless movement. A stop is incorporated in the circuit to allow complete muscular relaxation after each full movement. The resistance should not exceed

one half the weight a patient can lift ten times without discomfort Initially the muscles are exercised daily for two periods of four minutes and the weight and duration of the exercises are gradually increased as the power of the muscles improves

In the first few days after injury the muscles may be too weak to be exercised against resistance, or splints may prevent movement of joints In these circumstances static exercises are used, and they are especially valuable in the post-operative treatment of injuries of the knee joint In these exercises the muscle is tensed without moving

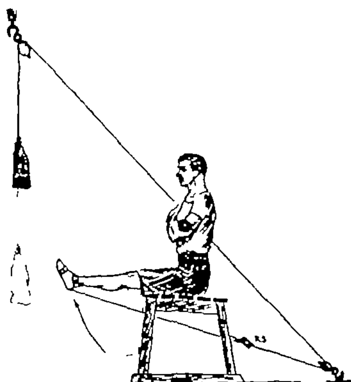


FIG 374

Weight and pulley circuit as used for exercising quadriceps muscle. R.S is a stop to allow relaxation of muscles after each full movement.

the joint the contraction is held for a few moments and then released, and is repeated twenty to thirty times every hour

Resisted exercises have certain disadvantages They tend to direct the attention of the patient to his disability and do not encourage normal use of the affected part Remedial exercises should therefore alternate with recreational therapy and occupational therapy It may be necessary to concentrate on one form of therapy in certain injuries Occupational therapy is particularly valuable in injuries of the hand and peripheral nerves where dexterity of movement is of the greatest importance On the other hand remedial exercises and competitive games are more useful in the treatment of injuries of the lower limbs and spine

Competitive Games.—Competitive games encourage spontaneity of movement improve muscular co-ordination and dispel mental apathy

(Figs 376 and 377) Furthermore the excitement of the game diverts the patient's attention from his disability The game or recreation is chosen according to the requirements of the individual and a steady progression is aimed at from mild exercise such as bowls



FIG 376

The human rowing boat game is excellent exercise for arm, back, and leg muscles.

(*By courtesy of British Machine Tool Engineering*)

and skittles to more strenuous games such as basket ball and volley ball (Fig 377)

Occupational Therapy—The patient is taught various crafts with the object of restoring the function of the injured part (Remedial Therapy) and to provide interesting employment which prevents introspective tendencies and the development of neuroses (Diversional Therapy)

(By courtesy of British Machine Tool Engineering)

FIG 376
Games such as tug-of war divert the patient's attention from his disability

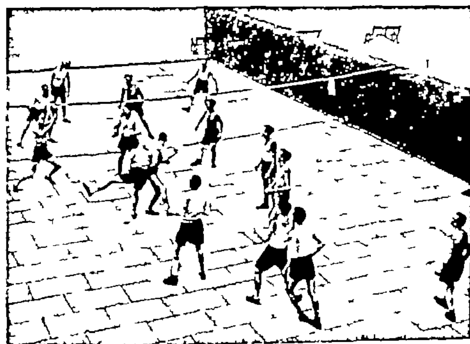


FIG 377
Volley ball is a suitable game for the final stage of rehabilitation. (Watson-Jones.)

Remedial Therapy usually alternates with periods of exercise and recreational therapy It ranges from light crafts such as cord knotting woodwork weaving and basketry to heavy occupations like cross-cut sawing and log splitting (Fig 378) The choice of craft depends on the patient's disability and occupation and the apparatus used is modified from time to time to ensure steady progression towards full recovery A patient with stiff fingers may be put to cord knotting At first the cord is held in a broad shuttle which is gradually reduced in size until finally the cord is held by the fingers alone Log splitting and cross-cut

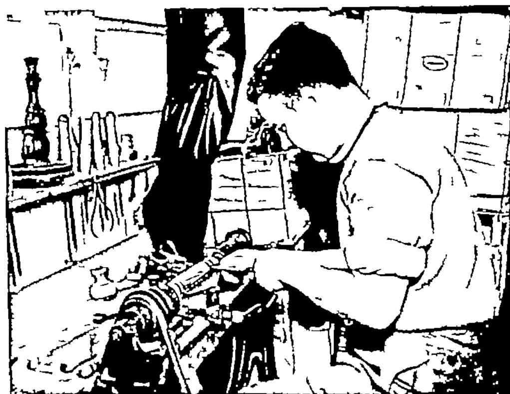


Fig 378

Occupational Therapy

A patient with a hand injury receives remedial therapy on a wood working lathe

(By courtesy of British Machine Tool Engineering)

sawing are reserved for workers in the heavier industries where physical fitness and endurance are of greater importance than manual dexterity

Diversional Therapy—Here is it essential to choose a craft which will hold the interest of the patient and prevent him brooding over his disability Diversional therapy should always be prescribed for patients who are confined to bed for long periods The most suitable crafts are weaving toy making knitting and embroidery (Fig 379)

Occupational therapy is not a completely satisfactory method of treatment for the sick or injured industrial worker For these patients a spell of modified employment in an industrial environment is often necessary to restore full working capacity For this purpose several of the major industries have established rehabilitation workshops which are discussed later

Psychological Factors.— Psychological insight and the ability to influence the minds of their patients for good are essential for all healers of the sick Recovery depends not only on efficient surgical treatment physiotherapy and reconditioning but on the steps taken to prevent the intrusion of the psychological sequelæ of disablement

Harmful suggestions or careless remarks made in the presence of a patient may be the beginning of a neurosis which is much more difficult to eradicate than the original disability The dangers of careless talk were very well described by the late Sir Farquhar Buzzard ' Medical practitioners must be alive to the psychological



Fig 370

Occupational Therapy

Diversional therapy for a patient with a severe traction injury of the right brachial plexus.

(By courtesy of British Machine Tool Engineering)

as well as the physical dangers of a patient who has been in an accident and take as much care to prevent infection of his mind with insidious morbid ideas as he does to prevent infection of his body with pathological organisms All who come into contact with the patient should endeavour to imbue him with the determination to get well.

REHABILITATION OF THE INDUSTRIAL WORKER

The majority of the sick and injured will make a full recovery and return to full employment within a reasonable time if treated in a hospital rehabilitation department Special facilities however are required for the patients from the heavier industries such as mining and shipbuilding which demand a high degree of physical fitness and endurance Special centres have been established in most of the

mining areas of Britain Here the patient lives and works in a healthy environment where each day is planned with the one object of returning him to his former employment Exercises and physical training alternate with organised games and heavier forms of occupational therapy which approximate in their physical demands to that of his own work Treatment whenever possible is arranged in the open air and is closely supervised by a resident medical officer, who must become acquainted with the problems of each individual patient and be able to instil in him the determination to get well (Fig 380) Every effort should be made to return the workman to industry immedi



Fig 380
Rehabilitation in Special Centres.
Exercises are performed out of doors whenever possible. (Watson-Jones.)

ately he leaves the centre for a few weeks idleness often results in a steady deterioration in his physical and mental condition with the result that he again becomes unfit for his former work.

RETURN TO WORK

On the conclusion of hospital treatment a functional analysis of a patient s disability should be carried out for the purpose of estimating his capacity for work Many patients will be able to return to their pre accident occupations but there are others who require a period of graded employment to complete their recovery The work must have a remedial value and the patient should remain under the medical supervision of the surgeon at the parent hospital. Where there is an industrial medical officer consultations should be held frequently with him for it is his responsibility to find the right type of work and enlist the interest and co-operation of the workshop foreman It is important that this modified employment should be

designed to help the man to progress towards his own job not to stabilise him at a lower economic level This is a matter of some difficulty in the heavy industries in which the only types of light work available are on such menial tasks as sweeping floors or night-watching

Rehabilitation workshops have been established in a few centres



FIG 381

Rehabilitation Workshop.

A patient with a stiff shoulder operates a fly press The hand grip can be raised to improve the range of abduction in the shoulder joint.

(*By courtesy of British Machine Tool Engineering*)

to facilitate the return of industrial workers to their former employment In these workshops lathes and machines are installed which can be modified by special attachments and fittings to suit the individual case (Fig 381) so that after a period of training he will be enabled to resume his own job

When it becomes obvious that a residual disability will prevent the patient from returning to his former employment a consultation should be held with the Almoner and the Resettlement Officer of the Ministry of Labour with the object of finding an alternative occupation for nothing is so prejudicial to a successful resettlement as a long period of idleness after the termination of treatment The prospects of a disabled man finding suitable employment have improved with the passing of the Disabled Persons Employment Act which requires employers to reserve a quota of jobs for disabled persons Moreover a disabled man may now receive a grant whilst training for a new vocation Several factors must be considered before advising an alternative occupation such as age previous training mental calibre and personality ability to travel by public transport and to climb stairs unaided, and the type of industry in the district where the patient resides Satisfactory employment can usually be found for a disabled man provided emphasis is put on what remains rather than on what has been lost and provided he is found a job which he can take and keep on his merits in competition with his fellows

Although relatively few in number the severely disabled constitute a problem of some magnitude in that they cannot be employed in ordinary industrial conditions They require to live near their work or be conveyed to work by special transport and are usually unable to work for more than a forty hour week. The tendency in the past was to concentrate too much on the disability rather than attempt to realise the full potential of the patient s working capacity which depends not only on what a patient *can* do but what he *thinks* he can do

Following a course of training at specially selected centres severely disabled persons can undertake watch and clock repairing boot and shoe making the manufacture of splints leather goods basket work, toys etc Provided a careful job analysis is undertaken and related to the patient s psychological and physical capacities then even the severely disabled can become producers of goods and services, be converted from public liabilities into civic assets and effectively re-established into family life

R B

designed to help the man to progress towards his own job not to stabilise him at a lower economic level This is a matter of some difficulty in the heavy industries in which the only types of light work available are on such menial tasks as sweeping floors or night-watching

Rehabilitation workshops have been established in a few centres

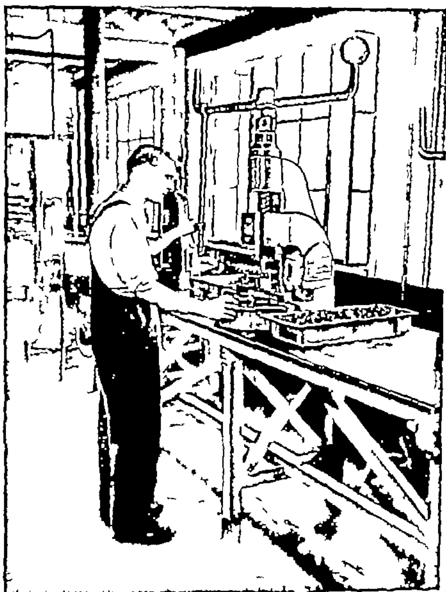


FIG 381

Rehabilitation Workshop.

A patient with a stiff shoulder operates a fly press. The hand grip can be raised to improve the range of abduction in the shoulder joint.

(By courtesy of British Machine Tool Engineering)

to facilitate the return of industrial workers to their former employment In these workshops lathes and machines are installed which can be modified by special attachments and fittings to suit the individual case (Fig 381) so that after a period of training he will be enabled to resume his own job

When it becomes obvious that a residual disability will prevent the patient from returning to his former employment a consultation should be held with the Almoner and the Resettlement Officer of the Ministry of Labour with the object of finding an alternative occupation for nothing is so prejudicial to a successful resettlement as a long period of idleness after the termination of treatment The prospects of a disabled man finding suitable employment have improved with the passing of the Disabled Persons Employment Act which requires employers to reserve a quota of jobs for disabled persons Moreover a disabled man may now receive a grant whilst training for a new vocation Several factors must be considered before advising an alternative occupation such as age previous training mental calibre and personality ability to travel by public transport and to climb stairs unaided and the type of industry in the district where the patient resides Satisfactory employment can usually be found for a disabled man provided emphasis is put on what remains rather than on what has been lost and provided he is found a job which he can take and keep on his merits in competition with his fellows

Although relatively few in number the severely disabled constitute a problem of some magnitude in that they cannot be employed in ordinary industrial conditions They require to live near their work, or be conveyed to work by special transport and are usually unable to work for more than a forty hour week. The tendency in the past was to concentrate too much on the disability rather than attempt to realise the full potential of the patient's working capacity which depends not only on what a patient *can* do but what he *thinks* he can do

Following a course of training at specially selected centres severely disabled persons can undertake watch and clock repairing boot and shoe making the manufacture of splints leather goods basket work, toys etc Provided a careful job analysis is undertaken and related to the patient's psychological and physical capacities then even the severely disabled can become producers of goods and services be converted from public liabilities into civic assets and effectively re-established into family life

R B

INDEX

Printed in Great Britain at THE DARIEN PRESS LTD *Edinburgh*